Fisheries technician Brian Ertel tracks radio-tagged Yellowstone cutthroat trout in the upper Yellowstone River.

Part III. Natural Resource Programs

This section describes the work accomplished or coordinated by YCR staff who comprise the following units of the Branch of Natural Resources:

- **Air, Land, and Water.** These staff are responsible for management, research, and monitoring of air quality, disturbed lands, and wetlands;
- **Aquatic Resources and Fisheries.** These staff are responsible for management, research, and monitoring of Yellowstone cutthroat trout preservation, westslope cutthroat trout restoration, health of fish and aquatic ecosystems, and angling;
- **Geology and Geothermal Resources.** These staff are responsible for management, research, and monitoring of geologic, geothermal, and paleontologic resources;
- **Vegetation.** These staff are responsible for management, research, and monitoring of rare plants, plant inventories and monitoring, vegetation studies, and integrated pest management; and
- **Wildlife.** These staff are responsible for management, research, and monitoring of wildlife, specifically bears, birds, bison, lynx, ungulates, and wolves.

Air, Land, and Water

Air Quality

Greater Yellowstone Area Clean Air Partnership. Resource management specialist Mary Hektner continued to represent the park in the Greater Yellowstone Area Clean Air Partnership. The partnership is comprised of representatives from Yellowstone and Grand Teton national parks, Gallatin, Custer, Beaverhead, Shoshone, Bridger-Teton, and Targhee national forests, Red Rock Lakes National Wildlife Refuge, the Idaho

National Environmental and Energy Laboratory (INEEL), and the Montana, Idaho, and Wyoming Departments of Environmental Quality. The partnership serves as an advisory group to the Greater Yellowstone Coordinating Committee and is a forum for information exchange to facilitate air program coordination and the implementation of consistent air quality management strategies.

Air emissions inventory. In FY03, the NPS Air Resources Division released a report entitled *2000 Air Emissions Inventory Yellowstone National Park Wyoming/Montana/Idaho*. The report summarizes the results of an inventory of air pollution emissions particulate matter (PM_{10}), sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), and volatile organic compounds (VOCs) that result from activities within the park. The inventory provides an understanding of the sources and magnitude of in-park emissions and a basis for contrasting them with emissions from the surrounding area, identifies existing and potential strategies to mitigate in-park air emissions, and evaluates the compliance of the park relative to state and federal air pollution regulations.

The inventory looked at stationary, area, and mobile emission sources within the park during the year 2000. Stationary sources include fossil fuel-fired space and water heating equipment, generators, fuel storage tanks, and wastewater treatment plants. Area sources include woodstoves, campfires, and wildland and prescribed fires. Mobile sources include vehicles operated by visitors, tour operators, and NPS and concessioner employees, and non-road vehicles and equipment.

Smoke from wildland fires was found to be the largest source of PM_{10} and carbon monoxide. Heating equipment was the largest source of sulfur dioxide, highway vehicles the largest source of nitrogen oxides, and snowmobiles the largest source of volatile organic compounds.

Winter air quality monitoring. Ongoing questions about oversnow vehicle emissions led to continued year-round monitoring of carbon monoxide (CO) and particulate matter ($PM_{2.5}$) at the West Entrance, and the addition of winter-season monitoring stations at Old Faithful and Flagg Ranch. National Air Quality Standards were not exceeded at any of the stations during the sampling period.

A team of scientists from the University of New Hampshire studying air pollutants in the park found that new, four-stroke snowmobiles and snowcoaches produce far fewer levels of emissions than conventional two-stroke snowmobiles (which are the primary source of volatile organic compounds (VOCs) and carbon monoxide pollution in Yellowstone during winter).

The study collected over 200 air samples from 21 sites throughout Yellowstone from February 12–16, 2003, using Environmental Protection Agency-approved methods. Approximately 85 different VOCs, including benzene and toluene, as well as carbon monoxide and methane, were measured. Even in remote park locations, levels of pollutants were substantial and carried the "fingerprint" of emissions from two-stroke snowmobiles, which substantially out-numbered the cleaner-burning four-stroke snowmobiles. The scientists recommended in their final report to the park that discontinuing the use of two-stroke snowmobiles, "will improve the air quality by reducing VOCs and carbon monoxide pollutants."

Mercury monitoring. Scientists from the U.S. Geological Survey, INEEL, and the universities of Montana, Wisconsin, and Nevada-Reno began a reconnaissance of mercury fluxes throughout Yellowstone. Fluxes were found to range from background to extremely high within acidic geothermal areas such as Roaring Mountain. There was great heterogeneity within thermal areas and between thermal basins. This range and complexity of fluxes makes it difficult to estimate a total flux

Turbid Lake Road prior to restoration, looking east, August 13, 2001.

from the Yellowstone geothermal system, and the scientists are seeking funding for additional studies. Atmospheric mercury concentrations were significantly lower than any health advisory levels.

Disturbed Lands and Mining Impacts

Turbid Lake Road. Restoration of the remaining three miles of the abandoned Turbid Lake Road between Turbid Lake and the East Entrance road began in 2002, using NPS Natural Resource Preservation Program Disturbed Lands Reclamation funding. Approximately 0.8 miles (3.7 acres) of the road was restored in FY03, the second year of a three-year project. To date, 1.8 miles (8.3 acres) has been restored, including the restoration of 13 separate wetlands. Original contours were re-established using an excavator and a bulldozer. The excavator also salvaged and placed topsoil and plant material to speed re-vegetation. Funds donated by Canon, U.S.A. paid for the Montana Conservation Corps to transplant grasses, forbs, and small trees. The project was delayed during a portion of the season because of the 21,000-acre East/Grizzly wildfire, which burned part of the project area. Trail reroutes accomplished last year were rebuilt due to fire damage. Despite the delay, the project should be completed in FY04, as planned.

Heritage Center site restoration. Funds generated from the sale of Yellowstone's 125th anniversary commemorative coins were successfully used for a non-government 1:1 match to apply for the Secretary of Interior's Cooperative Conservation Initiative.

Turbid Lake Road post-restoration, looking east, June 18, 2003.

Funds from the initiative and the matching "coin money" are being used to begin restoring native vegetation on five acres of the former Gardiner gravel pit—the site of the new Yellowstone Heritage and Research Center.

Historic mining impacts. Park staff continued to participate in planning and technical meetings, and to monitor proposed and ongoing reclamation projects associated with three mining areas located outside the park: the New World Mining District Response and Restoration Project, the McLaren Mill tailings, and the Great Republic Smelter.

Environmental cleanup of historic mining impacts in the New World Mining District adjacent to the park's Northeast Entrance is proceeding smoothly. The U.S. Forest Service continues to identify sources of pollution and conduct site investigations to refine cleanup activities. Resource management specialist Mary Hektner continued to serve as the Department of Interior's Project Coordinator for the New World project.

YNP and NPS Water Resources and Geologic Resources staff continued to work with the Montana Department of Environmental Quality to explore options for treatment and removal of the McLaren mine tailings and the Great Republic Smelter site, both located upstream and just outside the park's northeast boundary near Cooke City, Montana.

Wetlands

Wetlands mapping and delineation was completed along the 18.8-mile Norris-to-Golden Gate Grand Loop Road segment, the 1.0-mile Virginia Cascades Drive, the 5.1-mile North and South Canyon Rim drives, and the 0.5-mile Upper Falls Drive, as part of the parkwide road reconstruction program. Wetlands surveys were conducted along five backcountry trail reroutes, at five automated snow depth (SNOTEL) monitoring sites, two park construction project areas, and two frontcountry and seven backcountry areas slated for Wildland–Urban Interface hazardous fuels/forest-thinning treatments. The surveys were conducted to ensure that impacts to wetland resources would be avoided or minimized.

Revegetation and groundwater monitoring of ongoing work to restore the abandoned Turbid Lake Road to natural conditions continued in 2003. The results show that the Phase I restoration work, which

began in 1995, has been highly successful, as upland and wetland areas are beginning to revegetate with native plant species. Additional vegetation monitoring plots and groundwater wells to document wetlands restoration success were installed on the 0.75-mile portion of the Phase 2 road restoration completed this year.

Aquatic Resources and Fisheries

Yellowstone Cutthroat Trout Preservation

Lake trout removal. Following the discovery of lake trout (*Salvelinus namaycush)* in Yellowstone Lake in 1994, efforts have continued to intensify to counteract this non-native threat. Each year, gillnet operations staff has improved their knowledge of lake trout seasonal distribution patterns, as well as their ability to target lake trout while avoiding bycatch of native Yellowstone cutthroat trout *(Onchorhynchus clarki bouvieri)*. In 2003, the ratio of lake trout killed to Yellowstone cutthroat trout lost was very acceptable (1:0.11).

Since 1994, more than 75,000 lake trout have been eliminated in Yellowstone Lake via the gillnetting program. In 2003, over 18,000 lake trout were removed, using 20,657 net units (one net unit = 100 m of net set over one night). As in past years, lake trout carcasses were returned to the lake to avoid removing nutrients from this relatively nutrient-poor system. Using the NPS gillnetting boat, *Freedom*, and at least one other vessel on most days, the gillnetting effort has increased to greater than twelvefold over the 1999 level (Figure 1). Catch rate (catch per unit of effort) in 2003 remained very low (0.87) and was similar to that of 2002; catch rate has declined dramatically since 1998, when an average of 5.51 lake trout were caught each night in 100 m of net.

The majority of these fish have been netted in the West Thumb and Breeze Channel, which contain the highest lake trout concentrations, and where most of the gillnetting effort is targeted. Bioenergetics modeling (estimates of how many cutthroat trout a lake trout potentially consumes) suggests that an average mature lake trout will consume 41 cutthroat trout per year. Thus, the control project has saved a large number of cutthroat trout from lake trout predation.

The average total length of lake trout caught near the spawning areas indicates a long-term decrease in the length of sexually mature lake trout. However, the total number of spawning lake trout caught in 2003 was much higher than previous years due to the discovery of a new spawning location. The reduced annual catch of lake trout and reduction in average length of spawning fish are positive indications that gillnetting operations are exerting significant lake trout mortality in this system.

Although recent numbers from the lake trout removal program are encouraging, lake trout densities in the West Thumb remain high, posing a serious threat to the Yellowstone cutthroat trout. Model simulations indicate that a 60% or greater decline in the cutthroat population could be expected within 100 years if the lake trout population were permitted to grow uncontrolled. Research remains unsuccessful in developing a technique to remove lake trout in the mid-size range (400–600 mm total length). This component of the population coexists spatially with the cutthroat trout population, making it impossible

Gillnetting crew leader Barb Rowdon displays a 14-pound lake trout.

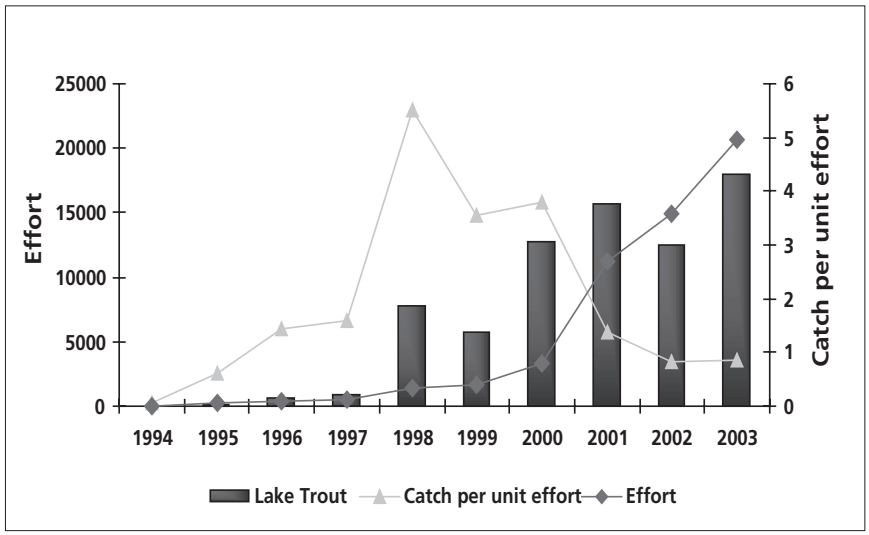


Figure 1. Graph showing decline in catch rate of non-native lake trout as effort increases—a positive sign for the gillnetting program.

to effectively gillnet them without also incurring an unacceptable mortality rate in cutthroat trout. In 2003, fisheries staff deployed fyke nets at lake trout spawning locations in an attempt to target this size class of lake trout. Fyke nets are generally a non-lethal collection method, and, if effective, would allow live release of any cutthroat trout also caught. Unfortunately, few lake trout were taken using this method. New methods to target this segment of the population before the fish reach full maturity and perhaps pioneer new spawning sites will continue to be investigated.

Long-term monitoring programs. Annual status of the Yellowstone cutthroat trout population in Yellowstone Lake has been assessed by counts of upstream-migrating spawners at Clear Creek, Bridge Creek, and Arnica Creek; by dipnetting adult spawners at LeHardys Rapids; and by a netting program on the lake conducted during September. Data collected in 2003 provided some of the first evidence in several years that the Yellowstone cutthroat trout population may be responding positively to efforts to remove non-native lake trout from Yellowstone Lake. An average of 7.4 cutthroats were collected per net in 2003, up from 6.1 fish per net in 2002, which was the lowest point recorded since 1969.

Examination of length-frequency data from the fall netting survey has indicated an annual, continuous loss of adult cutthroat trout numbers in Yellowstone Lake. In 2003, few fish between 300–430 mm in length were caught. Despite this, there has been an increase in juvenile cutthroat trout in recent years (2001–2003), viewed as an encouraging signal that the lake trout removal program's effects are significant, and making a major contribution to the preservation of Yellowstone cutthroat trout.

The recent Yellowstone cutthroat trout population decline also remains evident in total numbers of upstream-migrating cutthroat trout at Clear Creek, a major spawning tributary on the lake's eastern side. A total of only 3,432 upstream and 1,576 (46%) downstream migrating cutthroat trout were counted at Clear Creek during May–July 2003. The upstream count was down from 6,613 in 2002, and was the lowest count since only 3,353 cutthroat trout migrated upstream at Clear Creek in 1959 (a year that closely followed the discontinuation of egg taking operations on Yellowstone Lake). A fish counting station was also operated on Bridge Creek, a small northwestern tributary, where a total of 86 fish were counted migrating upstream and 46 (53%) were counted migrating downstream, late April-to-mid-June 2003. The number of spawning cutthroat trout continues to decline by more than 50% annually in Bridge Creek and has decreased by over 97% since counts began in 1999.

Whirling disease research. Recent work on *Myxobolus cerebralis*, the parasite that causes whirling disease, has shifted to intensive research on the apparent origin and potential source of infection in the Yellowstone River near Fishing Bridge, Pelican Creek (where infection is most severe), and Clear Creek. Disease spread is being evaluated through monitoring of tributaries with similar basin morphology to Pelican Creek, as recent survey results indicate that the spawning cutthroat trout population of this stream (which once numbered in the 10,000s of migrating fish) has been completely lost. Rigorous netting for migrating adult cutthroat trout in this stream in 2002 and 2003 turned up only a handful of fish. In addition, intensive searches for wild-reared cutthroat trout fry resulted in only nine fry found in 2003. Establishment of *M. cerebralis* in

Pelican Creek has contributed to the recent severe decline in the total Yellowstone Lake population of native Yellowstone cutthroat trout.

Hydroacoustic surveys to document population change. Surveys using hydroacoustic equipment for estimating fish densities were conducted throughout Yellowstone Lake twice during the 2003 field season. Partial surveys were completed three additional times to compare seasonal distribution of lake trout. Thorough analysis of this data will allow aquatics staff to determine areas of high density, size ranges of fish in given areas, and depths at which fish are residing. Graduate-level research has been initiated to relate these data with detailed bathymetry data produced by the U.S. Geological Survey. This research will identify specific lake areas where the lake trout gillnetting effort needs to be increased, and evaluate the effectiveness of removal efforts by estimating lake trout and cutthroat trout population densities annually.

Status of cutthroat trout in the Upper Yellowstone River. In 2003, the Aquatics Section and staff from the Wyoming Game and Fish Department initiated a fisheries assessment of the upper Yellowstone River. The study will determine movements of adult Yellowstone cutthroat trout during their spawning migration in the Yellowstone River and several of its tributaries. Existence of resident fish populations in the drainage will also be determined.

Radio transmitters were implanted in 62 adult Yellowstone cutthroat trout in the upper Yellowstone River basin. Tagged fish were monitored with weekly tracking flights and subsequent groundtruthing. Surveys to locate fish that moved into Yellowstone Lake were conducted via boat. Tagged Yellowstone cutthroat trout moved substantial distances through the summer of 2003. Fish from as far upstream as Thorofare Creek were found in the mouth of the Yellowstone River at Yellowstone Lake within just a few weeks—a distance of 31.5 stream miles. The majority of the tagged fish moved into Yellowstone Lake as the season passed. All fish moved downstream from the initial tagging position. The study is planned to continue for several more years.

Westslope Cutthroat Trout Restoration

Population surveys. Since 1983, park fishery personnel have been collecting information about westslope cutthroat trout *(Onchorhynchus clarki lewisi)* residing in Fan Creek, a tributary of the Gallatin River. This native trout was historically abundant in both the Gallatin and Madison river basins, but recent genetic surveys indicated that the most likely concentrations of genetically pure westslope cutthroat trout were located only in the headwater sections of Fan Creek. To obtain more detailed information about the remaining westslope cutthroat trout populations in the park, population estimates have been conducted annually since 1998 at several 100-m sections in the mainstem and each of the two forks of Fan Creek. Several years of sampling have shown that despite considerable annual variability, abundance of westslope cutthroat trout in much of the Fan Creek watershed is relatively low (<500 individuals per kilometer).

Genetics surveys. The apparent verification of a genetically pure population in the North Fork of Fan Creek encouraged NPS managers to proceed with development of a broodstock in cooperation with Montana and Wyoming state fishery agencies for eventual restoration projects throughout the upper Missouri River watershed. To be considered as a donor population, secondary verification of genetic status was recommended. To meet these requirements, tissue samples from 60 cutthroat trout each from 2001 and 2002 were analyzed in May 2003. Preliminary analyses suggested that the previously pure population in Fan Creek's North Fork had recently become hybridized with rainbow trout. With this new information, plans for collecting gametes on site in Fan Creek were temporarily cancelled. Additional samples obtained in 2003 have yet to be analyzed.

Restoration potential. Despite results of recent genetics analyses, the North Fork of Fan Creek population has high genetic integrity and should be considered an "at risk" population. To meet the park's restoration goals, additional information needed for preparation of an environmental assessment was collected in 2003. Aquatics Section staff completed habitat assessments, water quality sampling, and macroinvertebrate collections of the Fan Creek system this year. With the assistance of the park's geology staff, an onsite survey was conducted to ensure that the preferred site for the migration barrier on the main stem of Fan Creek was the most appropriate hydrological site. Aquatics Section staff

provided logistical support for Idaho State University researchers conducting amphibian surveys at several headwater lakes in the Gallatin River basin that could potentially be used as broodstock development of verified pure westslope cutthroat trout.

Stream Fishery Surveys and Fish Health

Population surveys. In 2003, a multi-year population assessment of Yellowstone cutthroat trout in Slough Creek was completed, prompted by concerns of perceived damage to riparian areas or the fish population arising from increased angler use. Electrofishing results indicated that there is little evidence that the abundance or size structure of the Yellowstone cutthroat trout population has changed since the stream was last sampled in 1989. Estimated abundance of adult cutthroat trout longer than 330 mm remains at several hundred fish per km. The recent capture of several potentially hybridizing rainbow trout of spawning size in areas of pure Yellowstone cutthroat trout appears to represent a much more serious threat to the long-term persistence of this population than the current levels of angler use.

Yellowstone cutthroat trout at Slough Creek.

Monitoring associated with road reconstruction. Because many park roads parallel streams, road construction projects can impact fish populations if excessive sediment is generated or improper culvert design impedes fish passage. In 2003, road reconstruction was initiated between Fishing Bridge and Canyon Junction and on the Dunraven Pass road. Several streams used by spawning and resident Yellowstone cutthroat trout are located within these construction areas. Cutthroat trout captured from the Hayden Valley sites exhibited growth rate characteristics similar to those found in the Yellowstone River, while the fish from Antelope Creek had lengths expected from a small headwater population.

For the fourth consecutive year, four locations in the Gibbon River between Gibbon Meadows and Madison Junction were sampled. The principal objective of this study was to monitor construction impacts to the stream during the Madison-to-Norris road reconstruction project, which has very high potential for increased sediment input into the stream and associated habitat degradation. This project also represents one of the first attempts by the park to restore a section of stream channel that was altered by historic road building. Although most of the Gibbon River was originally barren of fish, the sections downstream from Gibbon Falls historically contained westslope cutthroat trout and the riverine form of grayling. Grayling are still occasionally captured, and a secondary objective of the study was to document their responses to construction activities. Each year, brown trout were the most common fish collected at each sample area and the only species captured in the Tanker Curve section. During the past several low water years, estimated brown trout abundance averaged from 400 to 800 fish km^{-1}. Rainbow trout were only captured downstream from Gibbon Falls; several dozen individuals sampled in 2003 were longer than 450 mm. The four grayling caught in 2003 represented the highest number captured in three years. The widespread high density of brown trout probably contributes to the rarity of native grayling in its historic range in the Gibbon River watershed.

Surveys for fish health. In 2003, the Aquatics Section continued to participate in the U.S. Fish and Wildlife Service National Fish Health Survey to monitor the physical health of sampled fish populations that had not yet had a population level health diagnosis. In 2003, 40 brook trout and eight rainbow–cutthroat trout hybrids from the Middle Fork

of the Shoshone River were submitted and examined for a variety of parasitic infections and bacterial and viral diseases.

Another survey was conducted in Middle Creek, adjacent to a proposed construction area on the east side of the Sylvan Pass road reconstruction project, where the potential for spread of fish pathogens through construction activities is an important management consideration. Of even greater concern was the use of Sylvan Lake as a water source for fire suppression of the East Fire Complex in 2003. Because Sylvan Lake is a tributary of Clear Creek, where a low prevalence of whirling disease infection was found in 2000, the potential exists for the parasite to become established in this lake. Use of Sylvan Lake water for fire activities also increases the potential for whirling disease to become established in adjacent watersheds. In fall 2003, fishery personnel used gillnets to collect 25 cutthroat trout and four longnose suckers from Sylvan Lake for health analyses. Fortunately, the preliminary results suggest that whirling disease is not currently present in this lake. However, additional monitoring of the population may be necessary because Sylvan Lake has also been selected as the water source for dust abatement during the Sylvan Pass road reconstruction project.

Additionally in 2003, 35 cutthroat trout from the First Meadow area of Slough Creek were collected to complete the fish health survey of that basin which was initiated in 2001. Final results about the health status from these populations are pending.

Genetics surveys. In addition to the new samples collected from 135 suspected westslope cutthroats in the Fan Creek watershed, fishery personnel also obtained fin tissue samples from Slough Creek (n = 62) and Bacon Rind Creek (n = 25). There is a high probability that non-native rainbow trout have interbred with the native cutthroat at these sites.

Fin clips for genetic analyses were also obtained from Arctic grayling caught during the Gibbon River surveys. It is hoped that enough samples will be collected to examine whether there is a genetic difference between Grebe Lake grayling and fish collected in downstream areas that are presumed to be fluvial grayling. The Yellowstone Volunteer Flyfishing Program collected more than 100 additional genetic samples. Cutthroat trout were sampled in the Lamar River, lower Pebble Creek, and Beula Lake, which are waters with known or suspected areas of hybridization. Individual genetic analysis of these fish will assist in determining the distribution of hybridization in these native fish populations.

Aquatic Ecosystem Health

Long-term water quality monitoring. Water quality monitoring continued through 2003 at the 12 established stations on major river basins throughout Yellowstone National Park. Each site was visited once every two weeks with sampling days being randomly selected. A multiparameter probe was used to collect water temperature, dissolved oxygen (DO), pH, specific conductance, and turbidity. Water samples were also collected at each location for total suspended solids (TSS) and volatile suspended solids analysis.

Grebe Lake grayling.

During 2003, most parameters varied considerably within and between sites. Variations among water quality parameters were primarily due to diurnal cycles, high flows during spring snowmelt, rain events, seasonal temperature changes, altitude differences and thermal influences that affected many streams. Highest mean temperatures of 15.9°C and 15.4°C occurred on the Firehole and Gardner rivers respectively, both of which are thermally-influ-

enced streams. Lowest mean temperature of 4.3°C occurred on upper Soda Butte Creek. Highest mean DO concentrations of 9.2 mg L^{-1} were recorded for both the Gibbon and Snake rivers. The Firehole River exhibited the lowest average DO concentration of 8.0 mg L^{-1}. Pelican Creek, a tributary to Yellowstone Lake with low velocity, exhibited the lowest recorded DO concentration of 6.3 mg L^{-1}.

Within-site variation in pH was quite low, but variation was higher between sites. This is best illustrated in the Madison River drainage, which receives water from the Firehole and Gibbon rivers. Mean pH for the Firehole River was 8.3. This was the highest mean value for all sites sampled with the exception of the Gardner River, which also had a mean pH of 8.3. Conversely, the Gibbon River had the lowest mean pH at 6.8. Values for specific conductance, turbidity and total suspended solids (TSS) were highly seasonal and seemed to be directly related to river discharge. On average, specific conductance tended to be lowest during spring runoff, when water was more plentiful, thus diluting the ionic concentration of the water. Overall, streams having high specific conductance were associated with drainages that had considerable thermal contributions, with the Gardner, Firehole, Gibbon, and Madison rivers having the highest specific conductance of all sites sampled.

Turbidity and TSS were closely linked parameters. Higher turbidity values usually corresponded to spring runoff or localized precipitation events during summer months. Most sites had mean turbidity measurements below 10 nephlometric turbidity units (NTU), with the exception of Pelican Creek, which had a mean turbidity measurement of 10.8 NTU. The higher turbidity readings of Pelican Creek are most likely explained by higher phytoplankton concentrations in this slow moving stream. Yellowstone River at Fishing Bridge had the lowest mean turbidity measurement of 1.0 NTUs. Not surprisingly, this site also had the lowest mean TSS concentration of 1.2 mg L^{-1}. Lamar River exhibited the highest mean TSS of 21.2 mg L^{-1}.

Limnology of Yellowstone Lake. A total of seven sites are now sampled periodically on Yellowstone Lake to document changes in basic limnological characteristics. Water quality data were collected bi-weekly from late May until mid-October. Water temperature, dissolved oxygen, pH, specific conductance, and turbidity measurements were recorded using a multiparameter probe. Water samples were also collected at each location for total suspended solids (TSS) and volatile suspended solids analysis.

Water quality associated with winter use. During spring 2003, snowmelt runoff was sampled for concentrations of volatile organic compounds (VOCs). VOCs in snowpack are most likely produced by incomplete combustion of gasoline/oil fuel mix from two-stroke snowmobiles. This study was initiated to determine if VOCs were present in snowmelt. Sampling began after the 2002–2003 winter season, March 15–April 15, 2003. The study area was located within the road corridor between the West Entrance and Old Faithful. Three test sites were established within this area, with one site each in the vicinity of the West Entrance, Madison Junction, and Old Faithful. Selection of sample locations was based on the assumption that snowmelt was derived from snow that had originated from groomed roads. A fourth site was used as a control located in the Madison Junction vicinity on a small intermittent stream. Each site was visited nine times during the sampling period.

Sample analysis was conducted by the U.S. Geological Survey's laboratory in Denver, Colorado. Nine compounds within the VOC category were analyzed, including: benzene, ethylbenzene, ethyl tert-butyl ether, isopropyl ether, m-xylene/p-xylene, methyl tert-butyl ether, o-xylene, tert-pentyl methyl ether, and toluene. Of the nine compounds tested, only five were detectable within any given sample (benzene, ethylbenzene, toluene, o-xylene, and m-xylene/p-xylene). Samples collected from the vicinity of Old Faithful and West Entrance contained all five compounds during at least one sampling event. Highest levels for each compound were recorded near Old Faithful during early April 2003. This sample location drains much of the parking area utilized by visitors in the Old Faithful vicinity. The maximum recorded concentration for these five compounds were (units are μg L^{-1}): benzene, 0.031; ethylbenzene, 0.27; toluene, 0.61; o-xylene, 0.69; and m-xylene/p-xylene, 1.45. All VOC compounds for the Madison Junction site were below detection levels, probably due to large volumes of snow melting off adjacent hillsides and diluting VOC concentrations in snowmelt. The control site did contain trace levels

of toluene during six of the nine site visits. These results are similar to those of previous investigators, where trace levels of toluene were found in snowpack from off-road locations. The origin of this chemical remains unknown, and further studies are needed to evaluate its source. All VOC concentration levels were well below the EPA's level of toxicity to aquatic organisms.

Stone fly found during benthic macroinvertebrate sampling.

Macroinvertebrate monitoring. During 2003, benthic macroinvertebrate sampling continued for many streams in Yellowstone National Park. Sixteen stream segments were sampled in areas where major road construction is anticipated to occur during the next two years. In addition, 11 sites were sampled in the northwestern portion of the park. Nine sites were sampled within the Fan and Specimen creek drainages, with six sites sampled on Fan Creek and one set each collected from Crescent, Sedge, and Crag lakes. Invertebrate samples will be used to evaluate current condition of streams within the Fan and Specimen creek drainages and provide current inventory information and distribution patterns of aquatic invertebrates living within those drainages prior to any fish restoration attempt there. Also, two sites were sampled on Bacon Rind Creek in response to potential impacts from a fire retardant spill that occurred during September. These samples will be used to evaluate impacts to water quality as a result of that spill.

Ecologist Jeff Arnold uses a Surber net to sample invertebrates in the shallow waters of Bacon Rind Creek.

Angling in the Park

Trends from the volunteer angler report cards. Over 54,000 fishing permits were issued in 2003. A volunteer angler response (VAR) card is provided with each fishing permit, providing anglers the opportunity to report where they fish, what species and sizes of fish were caught, and their satisfaction with the fishing experience. There has been a response rate of almost 4,000 angler outings per year from the VAR cards. Data from 2001 and 2002 indicate that anglers fished 2.75 hours per day during typical fishing trips in the park. Single-day anglers reported catching at least one fish 78% of the time, and on average landed almost one (0.89) fish per each hour of fishing. Native cutthroat trout remained the most sought after and caught fish species making up 59% of the total catch, followed distantly by rainbow trout (15%), brown trout (9%), brook trout (8%), whitefish and lake trout (each 4%), and grayling (1%). The majority of anglers were satisfied with their overall fishing experience (75%), the numbers of fish caught (62%), and the size of the fish caught (68%).

An estimated 13,685 anglers fished Yellowstone Lake in 2002. The angler catch per effort for cutthroat trout in Yellowstone Lake is now at its lowest

level since summaries of VAR cards were compiled in 1979. Average total length is at its highest level since 1979. The change to this fishery coincides with the discovery and subsequent expansion of lake trout in Yellowstone Lake.

Anglers fishing the upstream section of Slough Creek catch cutthroat trout at twice the rate of those fishing the downstream section. However, the catch rate of fish in the upper section has been on a gradual downward trend. The length of trout caught in Slough Creek has not changed much in 35 years. Another noteworthy trend is the declining angler catch rate of Yellowstone cutthroat trout in Pelican Creek. Angler catch rate of cutthroat trout in Pelican Creek is currently one-third of what it was in the 1980s, likely due to loss of cutthroat trout fry due to whirling disease and predation by lake trout in Yellowstone Lake.

Public Involvement

Yellowstone Volunteer Flyfishing Program. Under this successful program, 74 volunteer anglers from across the United States traveled to the park and participated as an active component of the Aquatics Section. Volunteers experienced first-hand many fisheries issues, and biological data collected will assist in understanding the park's fisheries status.

In 2003, projects addressed by the Volunteer Flyfishing Program included:

- determination of the range of hybridized Yellowstone cutthroat trout in the Lamar River and its major tributaries;
- documentation of the Beula Lake fishery; and
- documentation of the status and movement patterns of grayling originating in Grebe and Wolf Lakes of the Gibbon River system.

Long-term volunteer assistance. The Aquatics Section recruits long-term (more than 12-week) volunteers from the Student Conservation Association and other sources. All aspects of the Aquatics Section greatly benefit from both long- and short-term volunteer support. In 2003, a total of 98 volunteers dedicated 4,041 hours to Aquatics Section activities.

Educational programs. Aquatics Section staff continued to provide a variety of educational programs for visiting schools and other interested groups. In 2003, six high school scholars from St. Steven & St. Agnes School, Washington D.C., and their leader, Mansir Petrie, spent over a week in the park interior working closely with NPS fisheries biologists, primarily on tributary spawning migration trap operations.

Collaborative Research

The Aquatics Section provides direct and indirect support for collaborative research with scientists at other institutions, primarily universities.

Graduate student projects. *Student:* Silvia Murcia (Ph.D. candidate). *Committee Chair:* Dr. Billie Kerans, Department of Ecology, Montana State University. *Title:* Relating *Myxobolus cerebralis* infection in native Yellowstone cutthroat trout *(Onchorhynchus clarki bouvieri)* with environmental gradients at three spawning tributaries to Yellowstone Lake in Yellowstone National Park.

Student: Lusha Tronstad (Ph.D. candidate). *Committee Chair:* Dr. Robert Hall, Department of Zoology and Physiology, University of Wyoming. *Title:* Decline in nitrogen transported by Yellowstone cutthroat trout spawning migrations.

Student: Carrie Brooke (M.S. candidate). *Committee Chair:* Dr. Al Zale, U.S. Geological Survey Cooperative Fisheries Research Unit and Department of Ecology, Montana State University. *Title:* Life history strategies of native westslope cutthroat trout in Fan Creek, Yellowstone National Park.

Other research and collaboration. The Aquatics Section continued to support a variety of other research projects. Of special mention is the research by the Great Lakes WATER Institute, University of Wisconsin at Milwaukee; Marquette University, Milwaukee; the U.S. Geological Survey, Denver; and Eastern Oceanics, Connecticut. Scientists from these institutions set up a laboratory at Lake and outfitted the NPS Aquatics Section boat, the *Cutthroat,* with a submersible remotely-operated vehicle in order to study the physical, chemical, and biological characteristics of Yellowstone Lake, especially its associated hydrothermal vent systems.

A limited number of Yellowstone cutthroat trout gametes were collected from McBride Lake (Slough Creek drainage) by Montana Fish, Wildlife and Parks, and from the Yellowstone River at LeHardys Rapids by Wyoming Game and Fish. In all cases, gametes are used for enhancement of

native cutthroat broodstock and restoration activities in Montana and Wyoming. Each year, age-zero Yellowstone cutthroat trout from the broodstock (LeHardys Rapids origin) in Wyoming are returned to the park for whirling disease exposure studies.

Geology and Geothermal Resources

Mission

The primary mission of the Geology Program is to protect Yellowstone's unique geologic resources, which include the park's landscape, rocks, minerals, fossils, and thermal features, and the geologic processes that form them. The program's growth and success is due to the help of part-time staff, partnerships, students, and dedicated volunteers.

Notable geologic events during the year consisted of three eruptions of Steamboat Geyser, the formation of a new thermal feature near Nymph Lake, and the "annual" thermal disturbance at Norris. Eruptions of Steamboat occurred on March 26, April 27, and October 23.

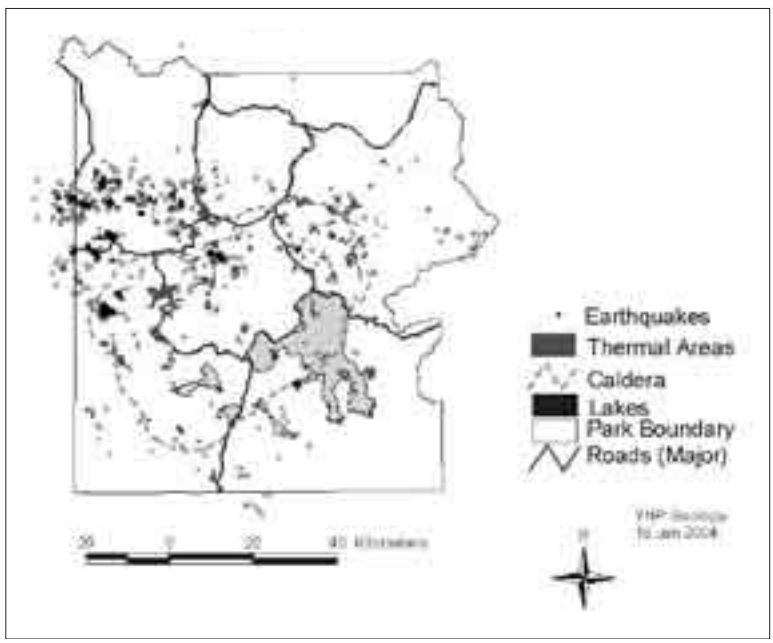
Hot Topics in Yellowstone Geology

Beryl Spring bridge. Thermal activity underneath Beryl Spring Bridge continued in 2003. Engineers replaced rotted and sheared wooden piers and laid down crushed quartzite. A crushed quartzite base for the new bridge piers allows steam to pass through the ground surface into the atmosphere, decreasing the trapping of moisture in the near-surface, and the formation of acidic conditions. YCR geologists continue to monitor changes in the area with temperature loggers and water flow measurements.

Earthquakes. During 2003, the Yellowstone area experienced 1,002 earthquakes—less than half the number recorded during 2002. In August 2003, several earthquakes of magnitude 2.2–4.3 shook the West Thumb–Grant area, concerning some residents. The sediments underlying this area cause residents and park visitors to feel small-to-moderate earthquakes more strongly than residents in other areas of Yellowstone. The earthquake of largest magnitude (4.3) occurred on August 24, at a depth of 3.5 miles, SSE of West Thumb.

Norris Geyser Basin. For the first time, the "annual" thermal disturbance at Norris Geyser Basin was documented by temperature loggers, which clearly showed that it began on July 11. Changes in the thermal activity of Porkchop, Pearl, and Vixen geysers and other thermal features were noted by the Norris Geyser Basin interpretive staff, YCR geology personnel, and volunteers during July and August. On these hot summer days, the sickeningly-sweet smell of cooking vegetation was especially prevalent in the area around Son of Green Dragon. At the time of the thermal disturbance, a new thermal feature near Son of Green Dragon erupted hot, acidic mud onto a portion of the Back Basin Trail. Concern for visitor safety prompted the placement of additional temperature loggers within the Norris area and the closure of some trails on July 23. The temperature loggers enabled YCR geologists to document and monitor the consistent, near-boiling (94°C, 199°F) temperatures.

Nymph Lake thermal activity. Forceful clouds of steam were noted issuing from a line of vents on March 10. The thermal activity could be easily seen and heard from the Norris-to-Mammoth road. The area of thermally-cooked trees became more visible



The Yellowstone area experienced 1,002 earthquakes in 2003.

New features at Nymph Lake, May 15, 2003.

throughout 2003, and the clouds of steam were twice mistaken for forest fires during the summer. Analysis of the steam clouds showed that they contained shards of glass, presumably from disaggregated Lava Creek tuff. When visiting the area, YCR geologists wore protective equipment to minimize adverse health effects on their lungs. Forceful clouds of steam were no longer visible on December 5, 2003.

Potential eruption of Yellowstone. During 2003, the media and general public became concerned about the possibility of a violent, catastrophic eruption of Yellowstone. New mapping of Yellowstone Lake and changes in thermal activity at Norris Geyser Basin spurred speculation about a cataclysmic eruption of the Yellowstone caldera. Analysis of monitoring data does *not* support the hypothesis that a large eruption is imminent. Yellowstone Volcano Observatory scientists continue to monitor Yellowstone's geologic hazards and share their information with the media, YNP personnel, resource managers, other researchers, and the general public.

Geothermal Monitoring Program

Chloride flux component. The chloride flux component of Yellowstone's Geothermal Monitoring Program continued during 2003. This component is integral to the park's Geothermal Monitoring Plan. With over 30 years of data, the chloride flux portion of the program provides continuous and baseline data for protecting Yellowstone's hydrothermal features. The chloride flux and real-time stream flow data is available through the Internet either at the Yellowstone Volcano Observatory website *http://volcanoes.usgs.gov/yvo/* or the USGS, Water Resources Division, Montana District website *http://mt.water.usgs.gov/index.html.*

Remote sensing component. The primary goal of the remote sensing component of the Geothermal Monitoring Program is to provide resource managers and park staff with timely, parkwide maps of annual changes in thermal features or thermal energy. Partnerships are being formed and technology is being applied that will improve the ability of park staff to efficiently monitor and protect its geothermal resources as well as display changes in thermal features or energy. A hand-held infrared imaging camera was tested on a portion of the closed Back Basin Trail. The infrared image, taken by Mitch Plummer of Idaho National Engineering and Environmental Laboratories (INEEL), clearly showed the hot, unstable areas within the trail. Other research groups used various platforms to generate rectified and calibrated images of thermal features. Preliminary imagery indicates that these efforts will assist park geologists in efficiently monitoring changes in Yellowstone's geothermal features and energy.

Hydrologic component. Groundwater in YNP is found in a variety of aquifer types: shallow alluvial, glacial, and shallow volcanic. These aquifers are loosely grouped and referred to as "cold water" aquifers. High-temperature geothermal fluids associated with magma bodies beneath and near the Yellowstone caldera are the other major component of the groundwater system in Yellowstone. Waters from the "cold" aquifers are part of the hydrothermal flow system that is heated and discharged in geothermal features throughout the park. The heated water may also mix with cold water locally. In order to understand short-term cyclical, catastrophic changes as well as long-term, natural, or anthropogenic changes to the Yellowstone geothermal system, both cold groundwater and geothermal systems must be monitored and assessed. During 2003, YCR geology personnel deployed and analyzed data from electronic temperature loggers and began monitoring "cold" shallow aquifers at selected locations.

Electronic temperature loggers. At the beginning of 2003, YCR geologists placed thermal loggers on Steamboat and Echinus geysers in Norris Geyser Basin. The temperature record of Echinus Geyser clearly showed the timing of the "annual" disturbance at Norris Geyser Basin. For example, Echinus Geyser erupted at irregular intervals before the

thermal disturbance, but exhibited a more predictable interval of three-and-a-half hours immediately after the thermal disturbance. NPS monitoring of near-surface ground temperatures along the Back Basin Trail showed near-boiling ground temperatures until October 2003, when a decrease in near-surface ground temperatures prompted the opening of the majority of the Back Basin Trail. The portion of the Back Basin Trail between Pearl Geyser and Son of Green Dragon continues to exhibit thermal activity and unstable ground. A reroute of this portion of the Back Basin Trail is planned for spring 2004.

Electronic database and catalog of geyser eruptions. Ralph Taylor, President of the Geyser Observation and Study Association and Volunteer-in-the-Park extraordinaire, deployed, maintained, and analyzed thermal loggers from June 17–October 16. These loggers allowed Ralph to predict eruptions of selected geysers for park interpreters and visitors. After October 16, YNP geology personnel continued to download data on many thermal loggers until Ralph returns during the summer of 2004. This data collection effort will show how selected geysers vary with seasonal changes, which is unprecedented. In addition to his work on thermal loggers, Ralph cleaned thermal features, interacted with visitors, maintained a catalog of thermal data for eight summer seasons, escorted researchers, monitored Potts Hot Spring Basin, consulted on geyser activity, mediated resource damage at Grand Prismatic Spring, and maintained an impressive log of his yearly activities.

Support of Park Operations

YCR geology personnel assisted with ongoing projects, provided training, and responded to requests from all park divisions.

Canyon Visitor Center. YCR geologists continued discussions with interpretive staff about exhibits for the new Canyon Visitor Center. In addition to reviewing and editing text, YCR geologists provided satellite images for exhibits.

Geologic reconnaissance of Fan Creek for possible fish barriers. Concern about native fish populations in the Fan Creek drainage prompted an assessment of its stream banks for suitability of fish barriers. During August, a field reconnaissance of Fan Creek was conducted. A hand-held GPS unit and clinometer were used to locate and assess possible sites along the Fan Creek drainage. Fifteen-minute quadrangle U.S. Geological Survey surficial geologic maps and other digital raster graphics were used as a base for mapping and as figures in an internal YCR report.

Geologic hazards and the wildland–urban interface. Concern about cutting trees at the wildland-urban interface near the park's East and Northeast entrances prompted a field meeting of landscape architects, resource managers, a YCR geologist, and other park personnel. YCR geologists expressed concern about excessive removal of trees at the East Entrance, which could endanger buildings, encourage bank instability, and destabilize landslides. Similar concerns about bank instability were expressed at the Northeast Entrance. Fifteen-minute quadrangle USGS surficial geologic maps were used as a base for mapping areas of concern and as figures in an internal YCR report.

Thermal image of Norris's Back Basin trail. Lightest spots show temperatures approaching 50°C (122°F).

Hydrothermal resource damage at Grand Prismatic Spring. The tragic crash of a light aircraft near Grand Prismatic Spring adversely impacted the hydrothermal resource. Henry Heasler, YNP supervisory geologist, assisted volunteer Ralph Taylor and resource managers from the park's West District to mitigate the damage at the spring.

Mammoth sinkholes. A laser-mapping tool was used to construct a detailed map of the sinkholes in front of the Albright Visitor Center. This map can be compared with future maps of the same area to show topographic changes within the karst terrain of Mammoth. The filling of sinkholes with sediments from Clematis Creek remains a concern.

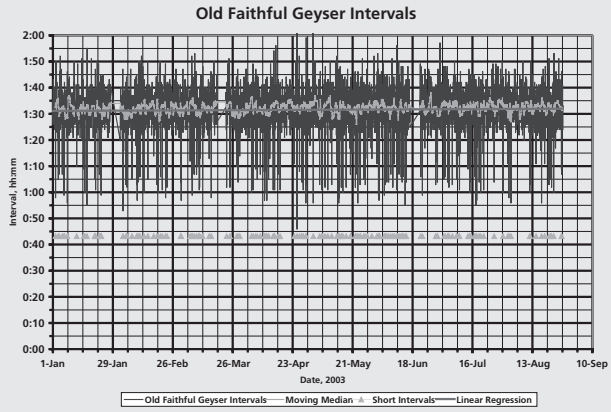
Activity from the 2003 Data Logger Record

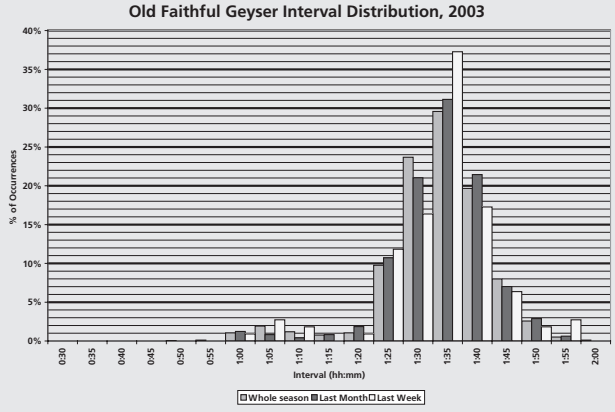
by Ralph Taylor

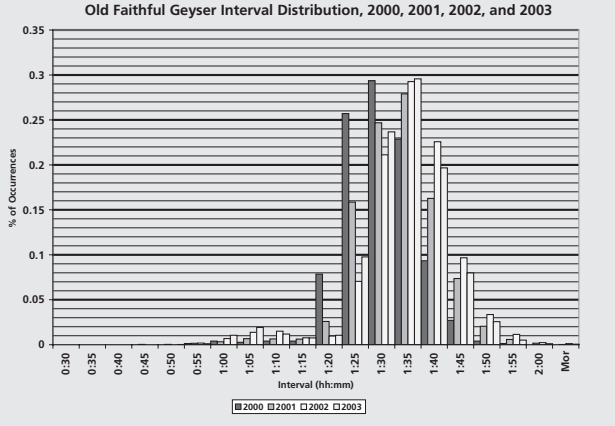
As of the end of September 2003, 36 loggers were deployed throughout the park. Some were on currently dormant or infrequent features (Steamboat Geyser, Silex Spring, Opal Pool, and Butterfly Spring), but most were on erupting geysers. There were 11 loggers on Geyser Hill, 12 in the rest of the Upper Geyser Basin, 1 at Black Sand Basin, 5 in the Lower Geyser Basin, 2 at Norris Geyser Basin, 2 at West Thumb Geyser Basin, and 3 at Potts Hot Spring Basin at the end of the summer. Forty-nine instruments had been deployed through the summer; 36 were deployed in mid-October. Some will remain in place all winter and only be downloaded in spring 2004, but most are being downloaded periodically over the winter. Summary statistics for most of the geyser data have been posted on the GOSA website *www.geyserstudy.org.*

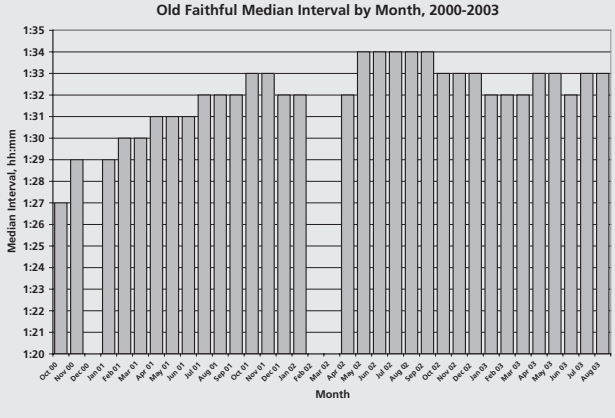
Old Faithful. Analysis of the Old Faithful data logger files showed that the mean and median intervals remained stable at between 91–92 minutes for most of the year. Temperature was recorded at one-minute intervals, and analysis showed that the electronically detected times were generally four or five minutes later than visually recorded start times, because of the delay in the hot water reaching the thermistor. The delay is constant within a minute, so intervals determined electronically agree well with logbook intervals. The sensor cannot determine the eruption durations, so long versus short intervals are determined strictly from the interval values themselves. For this analysis, all intervals of 75 minutes or less were defined as short.

There were 4,839 intervals measured in 2003. Of those, 237, or 4.51%, were short intervals. The longest interval was 124 minutes on April 25; this was the only interval over two hours. The shortest interval recorded was 46 minutes, also on April 25. There were 50 intervals of less than 60 minutes. Figure 10 shows the mean interval for each month for which logger data is available starting in 2000. In 2003, the intervals were essentially flat all year, with a slight seasonal peak in July. In general, Old Faithful had a stable, unremarkable year.









Norris Wastewater Treatment Plant Environmental Assessment. Blasting and excavation began in fall 2003 for the Norris water and wastewater treatment plants. Blasts were diffused through time to lessen any acoustic shock. All blasts were recorded on the nearby seismic station near the Norris water tank. No adverse effects to the Norris thermal system were found from the blasts. The excavations exposed highly-fractured Lava Creek Tuff.

Old Faithful Visitor Education Center. The proposed Old Faithful Visitor Education Center has the potential to affect the shallow hydrothermal flow of water. In an effort to determine the possibility of shallow hydrothermal water flow in the area of the proposed visitor center, 22 temperature sensors were deployed to gather data over the winter. These data are being analyzed to determine the presence of shallow subsurface thermal water flow.

Reese Creek. Henry Heasler consulted with resource management personnel and provided input on the operation and maintenance of the Reese Creek water measurement flumes. Pressure transducers have been purchased, and will be installed in Reese Creek to obtain an estimate of variation of hourly water flow.

Road construction. The Norris road construction is impacting a number of sensitive thermal areas. Geologic resources staff monitored construction activities in and near the thermal basins, including the Beryl Spring bridge. A thermal inventory of the road corridor north of Norris has begun. Preliminary airborne thermal images produced by Colin Hardy of the USDA Fire Science Lab were shown to the road team.

Theft of mineral specimens. YCR geologists continue to assist law enforcement rangers with identification of rocks and minerals believed to have been taken from the park.

Thermal activity affecting boardwalks and trails. At Norris Geyser Basin, ground temperatures, hollow ground, and hot, acidic mud continue to affect a segment of the Back Basin Trail near the Son of Green Dragon thermal feature. At Mammoth, discussions about boardwalks at Canary Springs, Blue Springs, and Palette Springs resulted in the movement of boardwalks at Canary and Blue springs. At Canary Springs, the new boardwalk allows thermal water to flow freely and expand its area of mineral deposition. Palette Springs continues to threaten asphalt and impact visitor safety by spreading thermal waters and minerals over the terrace trail.

Paleontology

Through the continued cooperative efforts of the Branches of Natural and Cultural Resources, the paleontological program provided a wide variety of services in FY03, including field inventory of new fossil localities, generation of draft documents reporting on two previous year projects, planning for the upcoming move of the fossil collection to the new museum facility, and the completion of the Paleontological Resource Inventory and Monitoring project. Elaine Skinner Hale, archeologist with the Branch of Cultural Resources, provided ¼ FTE, offering guidance, information, and program coordination. Julia Fitzke continued to provide paleontological services on a contract-for-services basis.

Trilobite Point Inventory. The Trilobite Point Inventory, funded by the Jane Smith Turner Foundation in association with the Yellowstone Park Foundation, was highlighted in the National Park Service's *Natural Resource Year in Review 2002*. This project provided management with the information necessary to protect and interpret fossil resources. This research effort was completed through partnerships and associations with Fossil Butte National Monument, the National Museum of Natural History (NMNH), the Yellowstone Gateway Museum, and a Russian paleontologist participating in an NPS International Volunteer program. YNP personnel from the ranger and interpretive divisions and several branches within the Yellowstone Center for Resources contributed time and equipment, insuring the wider success of the project.

The Trilobite Inventory project was presented at the 2003 Geologic Society of America convention, a widely-attended conference held in Seattle, Washington. The poster presentation focused on the Mount Holmes fossil survey, an inventory achieved by an interdisciplinary, interagency team of paleontologists, geologists, GIS specialists, and resource managers. The goal of this effort was to survey Middle Cambrian sedimentary rock units in search of 530-million-year-old invertebrate fossils. The presentation met with great enthusiasm from a number of paleontologists and geologists, some of whom discussed the need for interdisciplinary inventories

at other YNP localities and public lands.

The draft report of the Trilobite Point Inventory was reviewed by Arvid Aase of Fossil Butte National Monument and Dr. Ellis Yochelson of the NMNH. The final report is anticipated in 2004. Dr. Yochelson, at the NMNH laboratory, continued to reduce samples of the parent rock to expose microfossils for identification and density studies. Nine new fossil localities were located and documented, with the lithology and depositional environment for each location described. Fossil specimens recovered from the various localities included Agnostid, Ptychoparid, and Crepicephalus trilobites, numerous brachiopods, crinoid calyx, sponge spincules, hyolighids, and numerous trace fossils including worm burrows. Following accurate identification, significant specimens will be curated into the museum display. Fossils not displayed will be used for traveling displays and interpretation and learning programs. Contact between the geologic units of the Pilgrim Limestone, the Park Shale, the Meagher Limestone, and the Wolsey shale were also noted.

Paleontological resource inventory and monitoring. The establishment of baseline paleontological resource data is essential for the appropriate management of fossils found within YNP. Fossiliferous geologic units within the Yellowstone range from the Precambrian (approximately 550 million years ago) to the Recent, in which fossil invertebrates, vertebrates, plants, and trace fossils occur. The park's fossil resources also include fossil pollen, spores, marine and freshwater mollusks, dinosaurs, mammals, and a wide variety of petrified wood and fossil forests. These fossils have been recovered from more than 20 stratigraphic units in YNP.

Although a comprehensive paleontological resource inventory has not been conducted in YNP, a considerable amount of study has been devoted to Yellowstone's fossil resources, and continues to be conducted by outside investigators under the research permitting process. More than 70 researchers, representing approximately 40 different institutions, have received permits for conducting paleontological research in YNP. The 2003 publication, *Paleontological Resource Inventory and Monitoring, Greater Yellowstone Network*, by A.L. Koch and V.L. Santucci, contains a synopsis of Yellowstone's paleontological resources, a list of references to fossil research conducted in YNP, and a description of recent data sets. It is now available for management and research needs.

Mount Everts stratigraphy study. Participants in another interagency and interdisciplinary project, the Cretaceous stratigraphy and paleontological survey of Mount Everts, concentrated their 2003 efforts on laboratory analysis of the collected samples and specimens, and began drafting the text, compiling graphs and figures, and selecting photographs for the final report. The stratigraphy of Mount Everts, near the north entrance to YNP, contains deposits from sources on the coastal edge and the muddy bottom of the great inland sea from the Cretaceous Period, between 110 and 65 million years ago.

A Canadian laboratory was able to isolate fossil pollen from field samples taken on Mount Everts. Dr. Douglas Nichols, palynologist with the USGS and a member of the field investigation team, identified 14 species of pollen and 11 different spore species, as well as several species of dinoflagellates. This information helped identify non-marine (terrestrial) deposits, and provided more precise evidence of their age.

Brachiopods found during the Trilobite Point inventory.

Dr. Bill Cobban, paleontologist with the USGS, recovered highly fossiliferous coquina from the uppermost strata of the Muddy Sandstone, which yielded freshwater bivalves (four species), freshwater gastropods (three species), and a bivalve collection (seven species). Fish scales from three different species and a possible turtle bone were collected from the Mowry Shale, the next oldest depositional layer. Diagnostic bivalves and ammonites were collected from the Frontier Formation. Moving to the next younger sediments, the Cody Shale produced molluscan fossils of middle Coniacian age (between 88–87 million years ago) consisting of bivalves (five species), one species of gastropod, and two species of cephalopods. Crushed fragments of bivalves and scaphites were found in the Telegraph Creek Formation, and the younger Everts Formation produced a small freshwater bivalve.

Dr. Karen Porter, Chief Research Geologist with the Montana Bureau of Mines and Geology, developed an interpretation of the transgressions and regressions of the Cretaceous Interior Sea through the stratigraphy of Mount Everts. The team also recovered bentonite from Mount Everts that, after laboratory processing to evaluate argon loss, gave a mean age of 79.5 million years ago. The study identified the furthest northern locality of the Bear River Formation (equivalent to the Bear River Formation in southwest Wyoming) within the Muddy Sandstone on Mount Everts.

With the expert assistance of Dr. Thaddeus Dyman of the USGS, professional review of the findings was completed in 2003. Elaine Hale met with USGS team members in September 2003 to review the draft and identify information needed to complete the project. It is hoped that digital copies of the report will be available for professionals and the general public by fall 2004.

New finds. A result of intentional inventory and inadvertent discovery, several mammal bone fragments, some of which may be diagnostic, were recovered or reported in 2003. Dr. Cobban, while participating in fieldwork in the north central portion of the park, found a specimen of unidentifiable fossil mammal bone material in a silicified mud/sand matrix, secondarily deposited within a rubble slope.

Two additional independent discoveries of fossil bone material on a north-facing slope in the northern area of the park were reported in 2003. One large agatized bone fragment was removed from a bedrock outcrop by Dr. Cobban. Months later, in the vicinity, YNP historian Lee Whittlesey and concessioner employee Randy Ingersoll recovered several large fragments that appeared to be fossil bone. Investigation of the localities and a survey of the vicinity by a vertebrate paleontologist are indicated for the area.

In the south-central portion of the park, what were thought to be fossil bones were found in the Morrison Formation, which is Jurassic (200–145 million years old). YCR geologist Cheryl Jaworowski felt that the specimen may represent fossilized root casts. The location of the discovery is within the Snake River Fossil Region. The region warrants further investigation.

Collaboration. Yellowstone's paleontological program continues to benefit from its relationships with Fossil Butte National Monument, the United States Geological Survey in Denver, Colorado, the Smithsonian Institution and its National Museum of Natural History, the Montana Bureau of Mines and Geology, The University of Montana Department of Geology (through the CESU), and The Yellowstone Gateway Museum of Park County, Montana.

VEGETATION

The herbarium, a part of the museum collection, continued to be used extensively, especially during the summer months, both by park personnel and outside researchers. The herbarium collection now includes approximately 8,000 specimens of vascular and non-vascular plants that are all identified, mounted, and catalogued into ANCS+. During the 2003 field season, 469 specimens were collected to be mounted and catalogued into the herbarium. These specimens were needed to strengthen the collection, especially by documenting the native flora in under-collected portions of Yellowstone, as well as the arrival and spread of exotic species.

Rare Plants

Yellowstone sand verbena. Yellowstone sand verbena [*Abronia ammophila* Greene], is an endemic species of Yellowstone National Park that has a very restricted distribution along the shoreline of Yellowstone Lake. Because the total number of

individuals of this species is very low, one of the concerns associated with managing this unique plant is whether the sand verbena is dependent or limited by the presence (or absence) of pollinators. A research project funded by Canon, U.S.A.'s *Eyes on Yellowstone,* with a matching grant from the National Fish and Wildlife Foundation's Native Plant Conservation Initiative, enabled the park to contract with Dr. Sedonia Sipes, Assistant Professor, Department of Plant Biology, Southern Illinois University-Carbondale, to research the breeding system of Yellowstone sand verbena. During the summer of 2003, a combination of observational data and hand-pollination experiments were performed that will determine if *A. ammophila* has an autogamous, out-crossing, or mixed breeding system. These investigations were also designed to provide information on the floral phenology and the timing of stigma receptivity and pollen viability.

The data from the summer pollination experiments are currently being analyzed. It was observed last summer that the flowers open up at night and produce a noticeable scent, making access to individual flowers possible for pollinators. During the summer fieldwork, several potential bee and moth pollinators were observed visiting the flowers. These species will be identified during the winter months and examined for the presence of pollen. The viability of the pollen was investigated in flowers of various age. By the third day after blooming, the pollen was no longer viable, so pollinator visitation must be coordinated with the first or second day after the flower opens to be successful. The most interesting finding to date is that it appears that the plants are autogamous (self-compatible), and are apparently producing viable seed without any pollinator present. The actual viability of these seeds will be investigated with tetrazolium viability tests. This result is surprising, because other members of the genus that have been investigated were found to be obligate out-crossers.

Elizabeth Saunders helps conducts a hand-pollination experiment as part of research on Yellowstone sand verbena.

Ross' bentgrass. Ross' bentgrass [*Agrostis rossiae* Vasey] is a YNP endemic that is restricted to warm ground in the Upper, Lower, Midway, and Shoshone geyser basins. Casual observations had shown that this annual grass species is adapted to take advantage of the warm ground in the thermal areas by sprouting and beginning to grow during the winter months, blooming in early spring, and producing mature seed by the end of June. Since the entire global population of this species occurs in Yellowstone, learning more about the life history of Ross' bentgrass is imperative. A long-term study initiated in 1999 to investigate the ecological requirements of Ross' bentgrass was completed this year. The most surprising discovery of the project is that the ticklegrass [*Agrostis scabra* Willd.] that occurs in the thermal areas is very closely related to Ross' bentgrass, but not closely related to typical non-thermal ticklegrass [*Agrostis scabra*]. Actually, two separate species have been lumped together for over the last 100 years. The thermal ticklegrass is also practically indistinguishable from *Agrostis scabra* Willd. var. *geminata* (Trin.) Sw., which occurs at Lassen Volcanic National Park and *Agrostis pauzhetica* Probatova, which was considered an endemic of thermal areas in Kamchatka in Siberia. Apparently, there is a widely-distributed species associated with thermal areas for which the appropriate scientific name is uncertain. Ross' bentgrass was shown to be ecologically distinct from the thermal ticklegrass, with slightly different habitat requirements, including a difference in ability to tolerate acidity. This information

reinforces the need to continue to protect Ross' bentgrass as a unique taxon.

Rare plant surveys. The spray zone at the base of Tower Fall sustains three different rare plant species, including the only known location in the park of northern wood fern [*Dryopteris expansa* (Presl.) Fras.-Jenk. & Jermy]. When rockfall onto the old viewing platform precipitated a change in its location, several visits to the area were coordinated with the trails crew to help design a new viewing platform and trail system that would minimize impacts to the rare plants.

Teton anemone was found to occur in the park during a 2003 survey of the Gallatin Mountains.

Summer fieldwork concentrated on rare plant surveys associated with various construction projects throughout the park. The primary focus was on the Norris-to-Golden Gate road, along with the Virginia Cascades Drive. Two frontcountry construction sites were investigated for rare plants (the proposed new route for the Artist Paint Pot trail and the rock quarry site near Old Faithful). Additional surveys were initiated for other ground-disturbing activities, including five major backcountry trail reroutes surveyed at three different locations (Yellowstone River trail, Thorofare, and Shoshone Lake); the areas immediately adjacent to several SNOTEL sites; the immediate areas around seven different backcountry cabins and the East Entrance housing area for the Wildland–Urban Interface fuel reduction program; the area immediately adjacent to proposed speed bumps near Gardiner; and the area adjacent to a blocked road culvert (compliments of an industrious beaver construction project).

The summer field season resulted in documenting 120 additional sites into the rare plant GIS layer of "species of special concern," or rare plants in Yellowstone National Park.

Plant Inventories

New collections, alpine surveys, and clarifications resulted in a total of eight new native vascular plant taxa confirmed to occur within the park. Other researchers have reported several other species in the park, but these reports will need to be confirmed after examination of specimens.

In contrast to the previous three summers, when a total of 14 new exotic vascular plant species were discovered within park boundaries, only one new exotic species was detected this year. Euclidium, or Syrian mustard [*Euclidium syriacum* (L.) R. Br.], is a Eurasian weed that is established in the western portion of the U.S., including Wyoming, and was to be expected in the park sooner or later. The infestation was localized under the hitching post at the Hellroaring trailhead, and is small enough that it may be possible to eradicate it in the next few years. Hopefully, finding only one new exotic species this year heralds a change in the rate of new establishments that has been occurring in recent years.

One element of the servicewide Inventory and Monitoring initiative involves documenting at least 90% of the vascular plant species in each park. Although the current knowledge of Yellowstone's flora is within that goal, it has been acknowledged that the park region most likely to harbor species previously unknown to the park was the alpine zone, especially in the Gallatin Mountains. In summer 2003, a two-year Gallatin Mountains alpine plant survey was initiated. The field crew for the first eight-day trip included members of the vegetation unit, corral operations, and outside researcher Ken Aho. The group investigated the area in the vicinity of the Fawn Pass Cabin, including Fawn Pass, Snowshoe Pass, Bannock Peak, Gray Peak, and the Quadrant. The second, four-day trip was based out of the Sportsman's Lake cabin, and investigated the ridgecrest from Electric Pass to Joseph Peak. This summer's fieldwork resulted in the discovery of at least three previously-unreported species for the park: Teton anemone [*Anemone tetonensis* Porter ex Britt.] (also later located near Buffalo Plateau Cabin),

Kotzebue's grass-of-parnassus [*Parnassia kotzebuei* Cham. ex Spreng.], and Columbian stitchwort [*Minuartia austromontana* Wolf & Packer]. In addition, downy-fruited valerian [*Valeriana acutiloba* Rydb.var. *pubicarpa* (Rydb.) Cronq.] was confirmed to occur (specimen not available to be verified) in the park, along with a second location for beavertip draba [*Draba globosa* Payson].

The Thorofare is another under-studied area that yielded a number of new species in 2003. Previous reports of Wyoming paintbrush [*Castilleja linariifolia* Benth.] were based on a specimen in the Yellowstone herbarium that was in poor condition and not conclusive. Wyoming paintbrush was located growing on a bench near Cliff Creek in Thorofare, therefore confirming the occurrence of Wyoming's state flower within Yellowstone National Park. Letterman's needlegrass [*Achnatherum lettermanii* (Vasey) Barkw.] was located in Thorofare at two different locations, adding this inconspicuous grass to the park's species list. Another new taxon for the park, bristly mousetail [*Myosurus apetalus* Gay var. *borealis* Whittem.], a vernal pool specialist, was located in a depression near the Thorofare Ranger Station. A different variety of this species [*Myosurus apetalus* Gay var. *montanus* (Campbell) Whittem.] is known to occur in vernal wetlands in the northern portion of the park.

A Wyoming species of special concern, lanceleaf grapefern [*Botrychium lanceolatum* (Gmel.) Angstr.], was located during wetland delineation work along Obsidian Creek north of Roaring Mountain. This inconspicuous species is part of a challenging group that are difficult to distinguish and easily overlooked. Subsequent examination of the specimens of moonworts and grapeferns [*Botrychium* spp.] in the Yellowstone herbarium suggest that there may be other previously-misidentified species occurring in the park. It is hoped that a moonwort expert will examine the herbarium material in the coming year.

Four species have been removed from the park's species list. The YCR Annual Reports for 2001 and 2002 reported the discovery of several species of alpine plants previously unknown in the park. A check of the GPS locations revealed that several species (fan-leaved daisy [*Erigeron flabellifolius* Rydb.], arctic-alpine daisy [*Erigeron humilus* Graham], yellow mountain-heather [*Phyllodoce glanduliflora* (Hook.) Cov.], and dwarf buttercup [*Ranunculus pygmaeus* Wahlenb.]) were in fact collected just outside the unmarked park boundary. Upcoming surveys will look for the plants on park lands; until then, these four species will be removed from the park's vascular plant list.

Alpine Vegetation Study

A study to characterize alpine vegetation on volcanic substrates in the northeast corner of the park continued in 2003. This work is being done by Ken Aho, as a Montana State University master's thesis project. It is the first extensive plant ecological work to be done in the park's alpine zone of the Absaroka Mountains, and indeed, the first alpine vegetation study of any volcanic mountains in the central or northern Rocky Mountains. In addition to quantitatively describing 12 distinct alpine vegetation community types, Aho established permanent vegetation monitoring transects on nine mountains to establish a baseline from which the park can monitor potential impacts from exotic mountain goats, which are increasingly moving into and using the area.

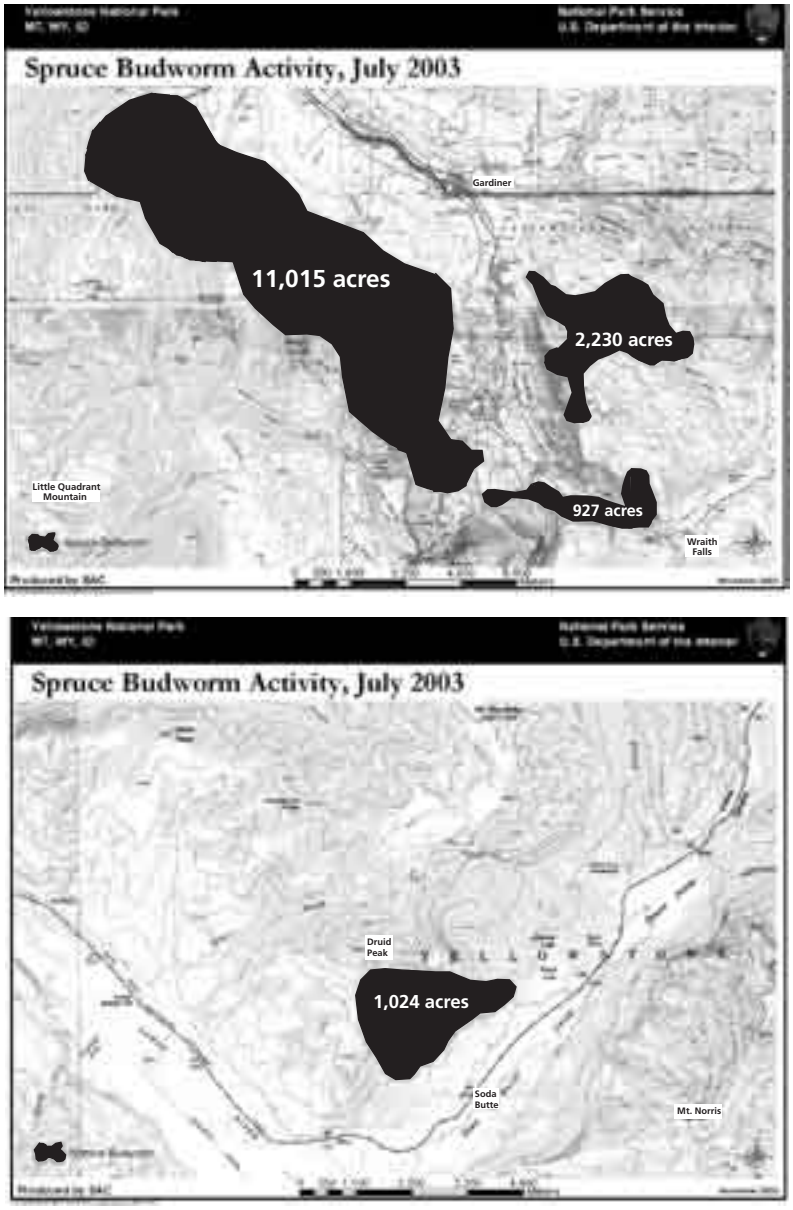
Vegetation Management and Research

Hazard tree removal. The management biologist performed hazard tree evaluations along the Tower–Canyon and Norris–Mammoth road corridors, where 1,200 and 364 trees, respectively, were marked for removal by Fire Cache and North District resource management personnel. He identified 16 additional hazard trees in the employee cabin area at Roosevelt Lodge that were removed by Xanterra and fire cache personnel. He also provided hazard tree management and removal documentation for two interrogatory requests and gave a court deposition related to a lawsuit brought against the park for personal and property damage resulting from tree failure in August 2000.

Inventory and monitoring. The management biologist actively participated in the development and ranking of vegetative indicators and vital signs as part of the servicewide Natural Resource Inventory and Monitoring Program being developed for the Greater Yellowstone Network parks (Yellowstone, Grand Teton, and Bighorn Canyon NRA). He attended three multi-day meetings related to program development, and provided logistical support for the third year of an exotic weed inventory of the park's northern range being conducted by a team from

Montana State University. He similarly coordinated logistics and toured potential sampling sites for the field inventory of bats in the park. Personnel from The Nature Conservancy's Wyoming Natural Heritage Program are conducting the field inventory.

Fire management. The management biologist participated in the management of fires during the active 2003 season, in which 77 different ignitions resulted in more than 28,000 acres burned. He provided short- and long-term fire behavior analyses, and flew daily aerial reconnaissance flights to map fire growth in support of fire behavior predictions. He further compiled daily fire situation reports to be broadcast nationally, and compiled fire weather and behavior forecasts for inclusion in daily shift plans. The management biologist also participated in the cooperative management of fires that crossed or had the potential to cross park boundaries. He participated as a member of an interagency GYA fire management working group to develop a consistent fire/fuels mapping database for fire behavior modeling application across all units, and participated as a member of the park's Fire Strategy Team to update the park's fire management plan and compile implementation plans and an Environmental Assessment for fuels treatments in the wildland-urban interface.



The management biologist documented 15,000 acres of spruce budworm activity in the northern portion of the park in 2003. Above, the Mammoth–Gardiner area; below, the park's northeast area.

The management biologist served as an instructor for the courses S130-190 (Introduction to Fire Behavior) and S290 (Intermediate Fire Behavior), held in YNP. He also provided field tours/lectures to 15 different university, professional, and public interest groups, including Laramie, Wyoming public radio, NBC-TV, and the Discovery and History channels, on fire ecology and management issues. He continued to serve as YNP's liaison with Montana State University researchers looking into the variability in fire regimes, forest structure, and fire effects in the Douglas-fir zone of the Greater Yellowstone Area.

Northern range issues. The management biologist initiated a study of the browse history of tree-sized aspen on the park's northern range as revealed by pith architecture, and continued with analysis of secondary metabolites in aspen tissue with cooperators from USGS-BRD and Brigham Young University. He also continued to work with researchers from Oregon State University and the University of Wisconsin at Stevens Point to describe woody (aspen) vegetation condition in relation to wolf/elk dynamics. Other research efforts requiring coordination and consultation with outside researchers included persistence and distribution of willows

on the northern range, establishment of a network of weather stations across the northern range, and assessment of the spatial and temporal effects of wolf reintroduction on aspen performance.

Integrated Pest Management

As the park's IPM Coordinator, the management biologist responded to 17 different pest complaints involving eight different taxa, and provided information and/or actions to mitigate or eliminate the problems. Pest complaints were associated with insects (7), small mammals (7), and spiders (3). He compiled Pesticide Use Logs for FY2002 and Pesticide Use Requests for FY2003, and submitted such documentation to the NPS's Washington Office.

The management biologist documented 15,000 acres of spruce budworm activity in the northern portion of the park in 2003, and compiled aerial maps showing the extent of budworm activity. He also represented YCR at one meeting of the GYA Whitebark Pine Committee to discuss survey needs regarding white pine blister rust, and attended one meeting of the Whitebark Pine Ecosystem Foundation to discuss whitebark pine status, trends, and research needs.

WILDLIFE

Bears

Population monitoring.

Grizzly bear recovery status.— At the end of 2003, all population recovery parameters for grizzly bears in the Greater Yellowstone Ecosystem were being achieved. The grizzly bear has been listed as a threatened species under the Endangered Species Act since 1975. The Grizzly Bear Recovery Plan sets forth three population goals that must be achieved before the grizzly bear will be considered for a status change within the Yellowstone ecosystem: 1) to have a six-year average of 15 adult females with cubs-of-the-year per year both inside the recovery zone and within a ten-mile area immediately surrounding the recovery zone; 2) to have 16 of the 18 Bear Management Units (BMUs) in the recovery zone occupied by females with young from a running six-year sum of observations, with no two adjacent BMUs unoccupied; and 3) to have known human-caused mortality not exceed 4% of the minimum population estimate based on the most recent three-year sum of females with cubs, minus known adult female deaths. In addition, no more than 30% of the known human-caused mortality can be females. To meet the recovery requirements, these mortality limits cannot be exceeded during any two consecutive years.

The three population goals outlined in the Grizzly Bear Recovery Plan were met in the Yellowstone ecosystem for the first time in 1994, but the mortality limits were exceeded in each of the next three years. The population goals were achieved again in 1998, and have been achieved every year since that time. A Grizzly Bear Conservation Strategy outlining how grizzly bears will be managed after de-listing has been completed and agreed to by all land and wildlife management agencies with jurisdiction over grizzly bear management in the GYE. A proposal to de-list the grizzly bear population in the Greater Yellowstone Ecosystem could be released as early as late 2004 or early 2005.

Bear sightings.— There were 1,547 bear sighting reports recorded in YNP in 2003. These reports included 876 observations of grizzly bears, 624 of black bears, and 47 where the species of bear could not be determined. In addition, there were 126 observations of grizzly bear sign, 12 observations of black bear sign, and 57 observations of bear sign where the species of bear could not be determined. The first observation of spring grizzly bear activity after den emergence was recorded on March 12, both in Pelican Valley and on Blacktail Plateau. The first black bear activity of the year was observed on March 23, at Fountain Paint Pot. The last grizzly bear activity observed prior to den entrance was recorded on December 6, in Lamar Valley east of the Buffalo Ranch. The last black bear activity was observed on November 6, along the Yellowstone River in the Canyon area.

Reproduction.— At least five females with home ranges either wholly or partially within YNP produced cubs in 2003. Those five females produced at least 11 cubs. Average litter size in YNP was 2.2 cubs per litter. There were 2 three-cub litters, 2 two-cub litters, and 1 one-cub litter. Some of these females had home ranges entirely within the boundaries of YNP, while others had home ranges that overlapped the park boundary. The five females with cubs counted in 2003 is lower than the long-term (1990–

2002) average of 12 females with cubs counted per year since 1990. Below average precipitation and whitebark pine seed production in 2002 likely contributed to low cub production in 2003.

Mortality.— At least one grizzly bear and three black bears were known to have died in 2003. All the mortalities were human-caused. No natural mortalities were detected. On June 14, at approximately 6:30 PM, grizzly bear #264, a well-known, highly visible, and very popular 12-year-old female, was hit by a vehicle on the Mammoth-to-Norris road a short distance south of the entrance to the Norris Campground. Bear #264 darted out in front of the vehicle. The driver braked and swerved to try and miss the bear, but hit it with the vehicle's right front tire. Bear #264 received multiple injuries, including a broken back and paralysis in the lower portion of her body. She was free-darted, taken to a veterinary hospital in Bozeman, Montana, and euthanized later that night. Bear #264 frequented the area between Mammoth and Norris, and was observed by hundreds, if not thousands of visitors each year. She was especially popular with photographers during years when she had cubs. Bear #264 was also the featured bear in the Animal Planet channel episode, "Seasons of the Grizzly." Bear #264 was very adept at killing elk calves in late spring and early to mid-summer, and was even observed killing calves as late as October. She was known to have had three litters of at least two cubs each—first in 1997, again in 1999, and a third and last litter in 2000. The first two litters did not survive. One of the cubs from the 1997 litter was killed by another bear. The only litter known to survive was the 2000 litter.

On June 16, a yearling black bear was hit and killed by a car near Calcite Spring. The yearling had been grazing in a meadow near the road when a large adult black bear approached and chased it toward the road. The yearling ran down a tree-covered embankment and onto the road, where it was hit by a pickup truck. The adult bear then came down the embankment and started to scavenge the yearling's carcass. On July 7, a black bear cub-of-the-year climbed up a power line pole near the Mammoth water treatment plant, touched the transformer, and was electrocuted. On August 9, a 125-pound black bear that had been crushing tents and climbing food poles to obtain anthropogenic foods was captured at campsite 9B9 in the Bechler area, flown out of the backcountry by helicopter, and chemically euthanized. In addition, the skeletal remains of a black bear that died due to unknown causes were found behind the Grant Village service station. However, the condition of the bones indicated that the bear had died the previous summer.

Bear foods monitoring. In 2003, the availability

Above, grizzly bear #264.
Right, staff of a Gardiner, Montana, motel mourn her loss.

of high quality, concentrated bear foods was poor during spring, estrus, and early hyperphagia, but good during late hyperphagia. The availability of winter-killed ungulate carcasses was below average in thermally-influenced ungulate winter ranges during spring, and the numbers of spawning cutthroat trout were below average during estrus. Early hyperphagia was characterized by drought conditions that caused vegetal bear foods to desiccate early. However, the abundance of whitebark pine seeds during late hyperphagia was higher than average. The abundance of whitebark pine seeds kept bears at high elevations and away from human activities during the fall, likely contributing to the low numbers of bear–human conflicts that occurred in the park.

Winter-killed ungulate carcasses.— Twenty-seven routes in ungulate winter ranges were surveyed to monitor the relative abundance of winter-killed ungulate carcasses available for bears to scavenge after den emergence in spring. A total of 3 bison carcasses, 28 elk carcasses, and 1 mule deer carcass were documented along the 275.3 km of survey routes completed. Twelve routes totaling 155.1 km were surveyed in low elevation northern winter range. Northern range carcass transect "L" was not completed due to a closure in effect to protect wolf den sites. Twenty-two elk carcasses, one bison carcass, and one mule deer carcass were observed, for an average of 0.2 ungulate carcasses per km of survey route. Grizzly bear sign was observed on four of the 12 survey routes, and black bear sign was observed on one. Bear sign that could not be identified to species was observed on two routes. The rate of 0.2 ungulate carcasses observed per km of survey route recorded on the northern winter range in 2003 equaled the long-term average of 0.2 ungulate carcasses per km recorded from 1997–2002.

Eight routes totaling 72.9 km were surveyed in the thermally-influenced ungulate winter range in the Firehole area. Two bison and three elk carcasses were observed, for an average of 0.2 ungulate carcasses per km. Grizzly bear sign was observed along six of the eight routes. Black bear sign was observed on one of the eight routes surveyed, and sign of a bear that could not be identified as to species was observed on one route.

Four routes totaling 24.1 km were surveyed in the thermally-influenced ungulate winter range in the Norris Geyser Basin. No ungulate carcasses were observed (0.0 ungulate carcasses/km). Grizzly bear sign was observed on all four survey routes; black bear sign was not observed on any routes.

Three routes totaling 23.2 km were surveyed in the thermally-influenced ungulate winter range in the Heart Lake area. No ungulate carcasses were observed (0.0 ungulate carcasses/km). Grizzly bear sign was observed on all three survey routes; black bear sign was not observed on any routes.

The overall rate of 0.04 ungulate carcasses per km in the areas of thermally-influenced ungulate winter range (Firehole Thermal Area, Norris Geyser Basin, and Heart Lake area) recorded in 2003 was lower than the long-term average of 0.28 ungulate carcasses per km recorded from 1992–2002.

Spawning cutthroat trout.— Park staff conduct cutthroat trout spawning surveys along eight streams within or near the Lake developed area and four streams within or near the Grant Village developed area, with the goal of monitoring the timing and relative magnitude of cutthroat trout spawning runs and associated bear activity along spawning streams. YNP uses the information to manage visitor use and set opening dates for recreational facilities in the Lake and Grant Village developed areas, which are adjacent to clusters of spawning streams. Management of recreational activities in these areas is done to reduce the potential for bear–human conflict. In past years, bear predation on spawning cutthroat trout in Yellowstone Lake tributaries within or near park developed areas has led to conflicts between humans and bears. In addition, spawning surveys are conducted on the Trout Lake inlet to determine the potential of this stream for fishing activity by bears.

In 2003, a total of 124 spawning cutthroat trout were counted during the peak week in the 12 monitored frontcountry tributaries to Yellowstone Lake. Grizzly bear activity was observed on three (25%) of these streams. No black bear activity was identified. The number of spawning cutthroat counted in each stream during the peak week in 2003 was lower than the long-term average for 1995–2002.

Cutthroat trout spawning activity began in the Trout Lake Inlet during the week of June 15. The last spawners in the inlet were observed in the last week of June. During the peak week of the spawn, 45 cutthroat trout were counted, significantly lower

Table 1. Bear–human confrontations reported in Yellowstone National Park, 2003.

SPECIES	AGGRESSIVE ENCOUNTER	APPROACHED PEOPLE	BEAR IN BACKCOUNTRY CAMPSITE	BEAR IN DEVELOPED AREA	TOTAL
Grizzly	10	8	5	27	50
Black	3	4	5	41	53
Unidentified	1	0	2	3	6
Total	14	12	12	71	109

than the long-term average of 309 spawners per year recorded from 1999–2002. No evidence of grizzly or black bear activity was observed in the area during the surveys.

Whitebark pine seeds.— Whitebark pine seeds are an important fall food for bears due to their high fat content and potential abundance as a pre-hibernation food source. During years with low availability of natural bear foods, especially fall foods, bears often seek alternate foods in association with human activities, and both the number of bear–human conflicts and human-caused bear mortalities increase. As part of an ecosystem-wide whitebark pine survey, cone counts are conducted at 19 whitebark pine transects within the Greater Yellowstone Ecosystem. YNP staff conduct cone counts on the 10 transects located within YNP. Cone counts at these 10 transects averaged 40.3 cones per tree in 2003. This was greater than the long-term (1987–2002) average of 13.5 cones per tree, per year, for all transects located within YNP.

Confrontations and conflicts with humans.

Bear–human confrontations.— Confrontations are defined as incidents where bears approach, charge, or otherwise act aggressively toward people, enter developments, or enter occupied backcountry campsites, without inflicting injury. These incidents are listed as confrontations due to the potential threat to human safety, even if the bears involved did not behave aggressively. Incidents in which bears injured people are listed in the bear–human conflicts section.

In 2003, there were 109 reported incidents of bear-human confrontations (Table 1). Grizzly bears and black bears were involved in 50 and 53 of the confrontations, respectively. The species of bear could not be determined for six confrontations.

Bear–human conflicts.— Bear-human conflicts are defined as incidents where bears damage property, obtain anthropogenic foods, or injure people. In 2003, there were 15 bear-human conflicts reported (Table 2). Ten of these incidents involved grizzly bears and four involved black bears. The species of bear could not be identified in one incident.

Bear management actions. In 2003, there were 559 bear-related incidents in which management action was taken (Table 3), including:

- 478 incidents where park personnel responded to roadside bear jams to provide traffic control, answer visitors' questions, and ensure that visitors did not approach or throw food to bears;
- 40 incidents where bears were hazed out of developed areas or away from roadsides due to concern from visitor safety;
- 22 incidents where trails, campsites, or other areas were closed to the public due to safety concerns related to bear activity;
- 17 incidents where bear warnings were posted at trails, campsites, or other areas due to bear activity;
- 1 incident where a grizzly bear was captured and translocated from a roadside auto campground; and
- 1 incident where a black bear was captured in a backcountry campsite and euthanized.

Table 2. Bear–human conflicts reported in Yellowstone National Park, 2003.

SPECIES	PROPERTY DAMAGE	ANTHROPOGENIC FOODS	HUMAN INJURY	TOTAL
Grizzly	7	2	1	10
Black	2	2	0	4
Unidentified	1	0	0	1
Total	10	4	1	15

Table 3. Bear management actions in Yellowstone National Park, 2003.

SPECIES	BEAR WARNINGS	AREA CLOSURES	BEAR JAM MANAGEMENT	HAZING	CAPTURE & TRANSLOCATION	CAPTURE & REMOVAL	TOTAL
Grizzly	13	20	146	14	1	0	194
Black	2	2	325	23	0	1	353
Unidentified	2	0	7	2	0	0	11
Total	17	22	478	39	1	1	558

Grizzly bear captures/relocations/removals.— One grizzly bear was captured in a management action in 2003. A subadult male grizzly bear that was suspected of crushing tents in the Bridge Bay Campground was captured, radio-collared, and translocated to Lewis River Divide. The 273-pound, three-to-four year old bear (#427) was not involved in any further conflicts for the remainder of the year.

Black bear captures/relocations/removals.— One black bear was captured in a management action in 2003. A 145-pound, adult female black bear that had been climbing food poles and crushing tents at backcountry campsites in the Bechler region of the park was captured at campsite 9B9. Due to human safety concerns, the bear could not be released back into the wild. When no zoo could be found to place the bear, it was euthanized.

Other wildlife management and monitoring activities.

Elk management.— In 2003, Bear Management Office (BMO) personnel immobilized one bull elk that had electric fencing tape wrapped around its head, antlers, and neck. The elk had been seen in the town of Gardiner for over two weeks. On August 13, it was observed inside the park near the North Entrance station. Due to the potential that the electric fencing tape might get caught up in brush or the antlers of another bull during rut-associated fighting or mock fighting, the decision was made to immobilize the elk and remove the fencing tape from its antlers. The bull was free-darted, immobilized, and the fencing tape cut from its head, antlers, and neck. The elk was then ear-tagged and released. In early September, the bull elk was shot and killed by a bow hunter outside the park.

BMO employee Travis Wyman baits and sets a live-trap for a food-conditioned coyote.

Coyote management.— BMO personnel assisted park rangers with removal of a food-conditioned coyote that bit two people at the Nez Perce Picnic Area. The coyote bit a woman on May 27, and a man on June 3. Following these incidents, the picnic area was closed and a live-trap set. After trapping operations were unsuccessful, the decision was made to shoot the coyote. BMO personnel periodically staked out the picnic area and searched for the coyote. On July 12, the coyote was spotted at the picnic area. Lake Area rangers responded to the scene and dispatched the coyote.

Road-killed wildlife.— A total of 96 large mammals (those that can attain weights of >30 pounds) were hit and killed by vehicles on park roads in 2003. Elk (29%, n = 28), bison (24%, n = 23), and mule deer (20%, n = 19) were the species most often killed in collisions with vehicles. Other species of large mammals hit and killed by vehicles on park roads included coyotes (14%, n = 13), moose (5%, n = 5), beaver (3%, n = 3), raccoon (2%, n = 2), grizzly bear (1%, n = 1), and black bear (1%, n = 1). The average rate of vehicle strike mortality for all park roads combined was 0.4 large mammal road-kills per mile of road. The highest vehicle strike kill rate was on U.S. Highway 191 (1.6 road-kills per mile of road), the only park road with a 55 mph speed limit. All other roads in YNP are posted at 45 mph

or lower. Highway 191 comprises approximately 7% of the paved roads in YNP, but accounted for 33% of the road-killed large mammals documented in the park in 2003.

Outreach. Park management recognizes visitor education as a key component in implementing the park's bear management program. The long-term survival of bears in the Yellowstone ecosystem depends on park visitors and surrounding communities having an understanding of bears and bear management practices. As part of this goal, the Bear Management Office presented 39 bear-related educational talks, field trips, and slide shows to various groups in 2003.

Birds

Threatened and endangered species.

Bald eagle.— In 1995, the U.S. Fish and Wildlife Service reclassified the bald eagle from "endangered" to "threatened" due to significant population gains made over the last three decades. In Yellowstone, a total of 24 eaglets fledged from 32 active nests during 2003. This equals the highest number of fledged eaglets, and breaks the record for active nests ever recorded in the history of Yellowstone National Park. As the Yellowstone bald eagle subpopulation continues to incrementally increase, territorial shifts and new nests are appearing in unexpected places. For the second year in a row, a pair of bald eagles took up residence on a nest 55 meters from the Madison-to-West Yellowstone road. This created quite an attraction for visitors, and kept wildlife managers and rangers on their toes with crowd control throughout the spring and summer. Also for the second consecutive year, this pair fledged one eaglet. Nest substrate instability caused by the 1988 Yellowstone wildfires resulted in minimal problems this year for nesting pairs. However, large numbers of trees are expected to topple to the ground over the next couple of decades, which will undoubtedly result in nest failure, loss of nest sites, or sudden changes in location of a nesting territory. Bald eagles have occasionally been documented taking over previously-occupied osprey nests, and the incidence of takeover appears to be gradually increasing due to competition for nest sites.

Bald eagle stalking prey.

Whooping crane.— The whooping crane is currently classified as an endangered species. The worldwide population consists of both wild and captive populations. This endemic North American species continues to rank as the rarest and most endangered crane in the world. Population figures as of summer 2003 placed the wild population at 300 cranes and the captive population at 132 cranes, for a total world population numbering 432. No whooping cranes now utilize the park.

Species of special concern.

Peregrine falcon.— On August 26, 1999, the peregrine falcon was removed from the list of threatened and endangered species. Under the provisions of the Endangered Species Act, this species needs to be closely monitored for five years after de-listing to ensure its recovery. The peregrine falcon is now managed as a species of special concern, and Yellowstone continues to be a stronghold for peregrines in the Northern Rockies. Three new eyries were found in 2003, bringing the total number to 23, compared to 20 eyries in 2002. Finding the new peregrine eyries allowed the park's ornithologist to record a total of 49 young fledged in 2003—the highest number of fledged peregrine ever recorded in Yellowstone National Park.

Trumpeter swan.— The YNP resident

trumpeter swan subpopulation continues to show signs of a species at risk of local imperilment. Swan recruitment from outside Yellowstone National Park is critical in maintaining the resident swan population; historically, swans that died in the park were eventually replaced by swans from outside the park (namely Montana's Centennial Valley, traditionally a hotspot for cygnet production). However, events over the last decade have led to a reduction in the number of breeding swans, particularly outside the park. Coupled with low numbers of fledged cygnets throughout the greater Yellowstone, these reductions are of serious concern. The number of subadult/adult swans in YNP has declined steadily since 1961, and currently stands at only 16 individuals. This is the fourth-lowest number of adults ever recorded in the park, and represents numbers reminiscent of the early 1930s.

Adult swan recruitment has been observed in the southern and northern portions of the park. However, no adult recruitment has been observed on the western portion; a lone adult female has been waiting for a mate in the 7 Mile Bridge area since February 2001. As of November 2003, this bird has been waiting a total of 33 months in the same area and has yet to find a mate.

In recent years, trumpeter swan nest attempts have ranged from 2–10 per year. There were only three swan nesting pairs in both 2002 and 2003, compared with two in 2001, seven in 2000, six in 1999, and nine in 1998. In 2003, four cygnets fledged from one brood in YNP. This was somewhat expected, because years with drought-like conditions are usually favorable for swan production. During two other severe drought years (1988 and 2000), Yellowstone National Park fledged seven cygnets each year. However, 2001 was a severe drought year, yet zero cygnets were produced. Except for these anomalies, cygnet production has been dismal over the last 14 years, ranging from 0–5 cygnets per year.

Adult swan recruits from Montana's Paradise Valley are helping to maintain the Yellowstone swan population for the time being. In 2003, there were three nesting pairs that fledged nine young from three broods in Paradise Valley. Of the 10 young that hatched, nine successfully made it to the fledgling stage. A fall survey of the Paradise Valley swans in 2003 tallied 22 individuals.

Molly Islands colonial nesting birds.— The Molly Islands Colonial Nesting Bird Census was conducted in mid-May, early June, early August, and mid-September 2003. The Molly Islands consist of two small islands, appropriately named Rocky Island and Sandy Island due to the nature of the substrate. The census techniques applied this year are consistent with those used over the last several years; however, both aerial and boat surveys were employed this year. Although this year's spring appeared to be late, American white pelicans arrived at the islands on schedule. On Rocky Island, a total of 130 pelicans initiated nests on the eastern (highest) part of the island. Nests were restricted to this one aggregation. Double-crested cormorants constructed 81 nests in the same area as the pelicans. The islands were free of flooding this year and snowmelt runoff was gradual. Of the 72 California gulls that attempted to nest, only 40 were successful in hatching young, whereas of the 6 nest attempts by Caspian terns, 5 were successful in hatching and rearing young. The following young fledged from Rocky Island: 64 American white pelicans, 183 double-crested cormorants, 77 California gulls, and 6 Caspian terns. Predation was not a factor on Sandy Island this year. Consequently, a total of 220 American white pelican nests were initiated, but only 160 nests were successful in rearing 264 young. Double-crested cormorant nest attempts were low, with 20 nests initiated and 12 successful in fledging 31 young. Pelicans nested in four distinct aggregations, two large and two small. No Caspian terns or California gulls nested on the island this year. In summary, 2003 was a year of surprisingly good colonial nesting bird production. Lake flooding did not occur due to the drought, which presented favorable conditions. Total production on the Molly Islands resulted in fledging 328 American white pelicans, 214 double-crested cormorants, 77 California gulls, and 6 Caspian terns.

Osprey.— The Yellowstone National Park osprey population continues to show signs of natural annual variation. In 2003, however, only 17 young fledged from 58 nests; a mere 24 young fledged from 83 nests in 2002. This represents the worst production ever experienced in the last 16 years of collecting detailed osprey population data. A series of strong winds throughout the summer caused many of the nests and/or nest trees to fall to the ground, resulting in high failure rates. This pattern has been occurring more frequently in the last four years. Tree nest

site instability and weather continue to play major roles in influencing osprey productivity in the park. Frank Island, a major osprey production area on Yellowstone Lake, has been out of favor recently due to nest substrate instability. The incidence of bald eagles taking over osprey nest sites was noted again this year.

Harlequin duck.— The harlequin duck population in YNP continues to maintain itself and is only mildly variable from year to year, with generally 16–24 nesting pairs residing in the park. Monitoring adults is the most effective method of keeping track of population vigor and trends. Monitoring annual productivity is not cost-effective, as data collection is extremely time-consuming and difficult due to the remoteness of many of the areas in which harlequins are found. Productivity is extremely variable from year to year and is highly influenced by weather, such as flooding.

Common loon.— Yellowstone National Park's common loon population continues to fluctuate from year to year. There were eight nest attempts in 2003, yet only one loonlet managed to reach fledgling age, compared to nine nest attempts and five fledglings in 2002, and nine nest attempts and seven fledglings in 2001. A total of 40 adults were found in the park in 2003, compared to 38 adults in 2002, and 36 adults in 2001. These adult numbers have reliably ranged from 34–51 individuals over the last 15 years. Yearly fluctuations in adult numbers and in the production of young are thought to be the result of variable weather conditions.

Population monitoring.

North American Bird Migration Count.— Yellowstone National Park participated in the North American Bird Migration Count for the 11th consecutive year in 2003. Originally designed to collect quantitative and qualitative spring bird migration information on a continental scale, the count has turned into a low-key social event. The survey is traditionally scheduled on the second Saturday in May each year. This year, the count was conducted on May 10. Four observers recorded a total of 3,630 individual birds. A total of 78 species of birds were recorded during the count, including 57 species within YNP.

Mid-winter eagle survey.— The annual mid-winter bald eagle/golden eagle survey was conducted for the 17th consecutive year in YNP and on portions of the northern range outside the park. A total of 83 eagles were counted on January 10. Of the total, 76 were identified as bald eagles, and seven were identified as golden eagles. Seventy-one of the 83 total wintering eagles were found in the Jardine/Gardiner/Mammoth area. The northern range outside YNP continues to be the hotspot for wintering eagles, at least in part due to carrion availability from the regular- and late-season elk hunts. Weather continues to play a major role in eagle distribution, as does prey and carrion availability.

Breeding Bird Surveys.— Three Breeding Bird Surveys were conducted in 2003. This songbird data was sent to the continental database clearinghouse located at the Patuxent Wildlife Research Center in Laurel, Maryland, and is included in information available online at *www.mp2-pwrc.usgs.gov/bbs*. Data from these surveys are used to develop population trends for North American songbirds. YNP Breeding Bird Surveys date back to 1982.

Christmas Bird Count.— On December 21, 2003, the Yellowstone Christmas Bird Count (YCBC) was conducted in the Gardiner, Montana, and Mammoth, Wyoming, areas, marking the 31st year for this traditional winter bird survey. The 2003 Yellowstone Christmas Bird Count tallied a total of 42 bird species and 2,134 individual birds—the second-highest number of species and fourth-highest number of individuals ever recorded on count day. Temperatures ranged from 20–42°F, with 0–8 inches of snow, depending on the elevation. River edges were not frozen. Two new species of wintering birds were detected; on count day, a bufflehead was found along the Gardner River in Montana, and a Lincoln's sparrow was found at a bird feeder in Gardiner, Montana. Several bird records were tied or broken during the 2003 YCBC. Tied records included: 6 northern flickers (previous record set in 2002); and 1 white-crowned sparrow (previous records set in 1991, 1992, 1994, and 1998). Five records were broken. New abundance records included: 4 marsh wrens (previous record was 2 in 2000 and 2001); 3 gadwalls (previous record was 2 in 1995); 68 common goldeneyes (previous record was 27 in 1975); 2 northern goshawks (previous record was 1 in 1976, 1985, and 1990); and 132 Townsend's solitaires (previous record was 106 in 1988). A grand total of 97 species have been recorded on the YCBC (102 species with count day and count week com-

bined) during the 31 years the count has taken place. Experience shows that colder temperatures and above average snow depths are the optimum conditions for finding the greatest bird richness and abundance during the YCBC. Details on past Yellowstone Christmas Bird Count methods, results, and summaries can be found in the Winter 2001 and Winter 2002 issues of *Yellowstone Science*.

Birds added to the park checklist. Three new bird species were added to the Field Checklist of Birds of Yellowstone National Park in 2003. On November 26, the staff ornithologist observed a whooper swan (*Cygnus cygnus*) in second winter plumage in Hayden Valley. This is the first whooper swan record for YNP and the state of Wyoming. Photographs were taken of this misplaced bird to accompany detailed written documentation. This swan is believed to be wild, as it was with marked swans from northern Canada, and arrived following a major cold front event. Whooper swans are endemic to Iceland and Eurasia, but occasionally make it to North America. This finding is significant, because it shows how difficult it is to compartmentalize populations into geographic groups, because waterfowl are notorious for long-distance migration and constant mixing. The staff ornithologist detected a lesser goldfinch (*Carduelis psaltria*) on the west shore of Yellowstone Lake on October 10. A previous record of a bean goose (*Anser fabalis*) detected in September 2000 topped off the list. More details of these and other new finds can be found in an upcoming issue of *Yellowstone Science*. As of 2003, 319 species of birds have been documented in the park since it was established in 1872. The Field Checklist of Birds of Yellowstone National Park was last revised by the staff ornithologist in April 2000. A newly-revised bird checklist was made available to the public in March 2001. This checklist is available on the park website at *www.nps.gov/yell*. Updates to this checklist and the website are scheduled for March 2004. Other interesting and/or unusual Yellowstone bird finds for the year include a Richardson's Canada goose on Yellowstone Lake in April; a black and white warbler near Mammoth in June; two Hudsonian godwits on the north shore of Yellowstone Lake in August; a Nashville warbler near Mammoth in September; a Pacific loon at Heart Lake in September; a small flock of western bluebirds near the 45th parallel in February; a northern mockingbird each at Old Faithful and in Lamar Valley in May; and a scissor-tailed flycatcher on Upper Slough Creek in August.

The whooper swan was added to the park bird checklist in 2003.

Bison

In FY03, the Bison Ecology and Management Office (BEMO) continued collaboration with partner agencies to implement the Interagency Bison Management Plan (IBMP). Twelve hazing operations were conducted in the park to manage bison distribution. Throughout the winter months, BEMO staff monitored bison abundance and distribution near the two boundary areas where egress is most common. When spring snow conditions resulted in a movement of approximately 250 bison to near the park's northern boundary during the first week of March, a weeklong capture operation resulted in the removal of 231 bison from the park. Interagency communication planning resulted in the first ever interagency news release explaining

Table 1. NPS bison management activities, 2003.

		TOTAL NUMBER OF PERSONNEL DAYS		PERSONNEL TIME PER EVENT (HRS)			PEOPLE PER EVENT	
MANAGEMENT ACTIVITY	NO. OF EVENTS	YCR STAFF	RANGER ACTIVITIES STAFF	TOTAL PERSONNEL TIME (HRS)	MEAN	RANGE	MEAN	RANGE
Aerial flights	8	7	0	57	7	5–8	2	1–2
Capture	12	31	2	262	22	2–44	3	1–7
Field dispatch	2	0	0	1	1	0–1	1	1
Hazing	44	10	77	696	16	1–56	4	1–12
Law enforcement	7	0	33	266	38	1–88	4	1–8
Monitoring	88	204	7	1,686	19	1–60	3	1–7
Remote vaccination project	75	327	0	2,619	35	6–112	3	1–7

Hours and days are rounded to nearest whole number
Personnel day = 8 hours

the partnership and commitment to the management goals set forth in the IBMP.

A diverse field program continues to gather information for management-related decision-making and monitoring of long-term ecological parameters. Progress was made in developing a remote delivery vaccination program by investigating the capabilities of currently available remote delivery equipment and developing new methods of encapsulating the vaccine. A study of bison movement patterns, initiated this year, should provide information to assess the feasibility of remote vaccination and the extent to which bison use road corridors for winter travel. BEMO staff monitored demographic parameters such as birth rate, age-specific mortality rates, and disease prevalence. A summer count of the bison population resulted in an estimate of 4,250 individuals, of which 640 were calves-of-the-year that survived to August.

Implementation of the Interagency Bison Management Plan.

Human resource allocation.— NPS-conducted management activities consisted of seven tasks (Table 1). These tasks were divided among staff in both the Yellowstone Center for Resources and the Division of Resource Management and Visitor Protection. This year, primary efforts were devoted to research and development of a feasible remote delivery system to vaccinate free-ranging bison throughout Yellowstone. Definitions of management activities identified in Table 1 are as follows:

Aerial flights. Aerial flights for location monitoring during winter. The YCR conducts flights for estimating the abundance of the population and monitoring the abundance and distribution of bison in management monitoring zones.

Capture. Capture of bison in the Stephens Creek, Horse Butte, or the Duck Creek facilities.

Field dispatch. Field dispatch occurs when the NPS lethally removes a bison for health, safety, humane, or IBMP-related reasons.

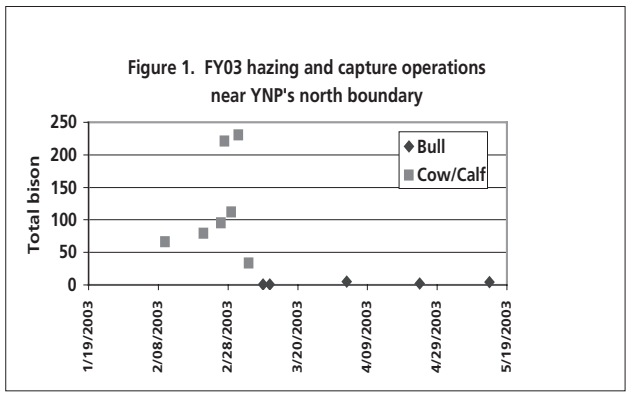
Hazing. The process of herding/moving animals to a new location. Ranger staff supervises all hazing actions at the north boundary, and assists the Montana Department of Livestock at the west boundary.

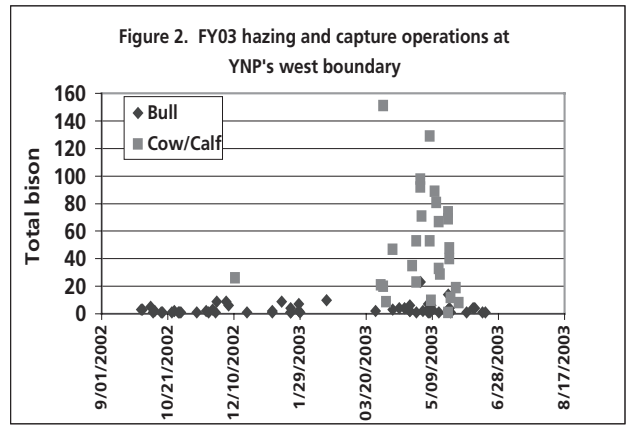
Law enforcement. Law enforcement activities can range from monitoring protestors to assisting a hazing operation by stopping traffic.

Monitoring. Monitoring consists primarily of Ranger or BEMO staff looking for bison from wheeled vehicles or snowmobiles, and noting their number and location. Ground monitoring is focused on the area from Hellroaring Creek overlook west and north, Swan Lake Flat, and along the Madison River from Madison Junction west.

Remote vaccination project. This project consists of time spent, primarily by BEMO staff, developing the methodologies for the future field vaccination of bison. Activities include documenting bison behavior when approached by humans, gaining an understanding of available remote delivery equipment, and working on methods for improving efficiency of remote vaccination delivery.

Managing the risk of disease transmission.— Implementation continued to focus on spatial and temporal separation of bison and cattle outside





national park boundaries. The BEMO recorded interagency activities and compiled 24 bi-weekly reports of actions, which were distributed to park staff and partner agencies. Ninety-eight hazing operations were conducted this year—12 at the north boundary (Figure 1), and 86 at the west boundary (Figure 2). Fifty-eight percent of hazing operations along the north boundary involved movement of groups of mixed age and gender. At the west boundary, mixed-group hazing operations accounted for 33% of all hazing operations conducted. Average size of mixed age/gender groups was 120 (north boundary) and 50 (west boundary). During the first week of March, 231 bison were captured in the Stephens Creek capture facility and consigned to the Montana Department of Livestock for transport to slaughter plants in Montana. These animals were tested for brucellosis by collecting post-mortem blood samples at the slaughter plants. Forty-three percent of these bison tested positive for brucellosis.

Monitoring abundance and distribution during winter.— Bison abundance and distribution in the special management zones defined in the IBMP were monitored through monthly aerial surveys from November through April, depending on suitable weather conditions. Bison abundance peaked in the northern boundary areas in February; activity in the west boundary area peaked in May (Table 2). Table 2 shows the number of bison counted in each zone identified in the IBMP, and in several other areas where bison are monitored as per the Interagency Field Operating Procedures established for IBMP implementation.

Population estimation.— Population estimates were conducted in March and August to monitor seasonal population size. Aerial counts surveyed

Table 2. YNP bison management zone summary, 2003.

NORTHERN MGMT ZONE	OCTOBER 2002	NOVEMBER 2002†	JANUARY 2003	FEBRUARY 2003	MARCH 2003	MAY 2003
Outside park (zone 2)	0	0	0	18	34	5*
IBMP zone 1	0	0	0	0	3	9*
Tower/Hellroaring/Mammoth	19	10	550	718	297	201[1]
Swan Lake Flat/Roaring Mountain	120	107	378	268	52	36*
Total	139	117	928	1,004	386	251[2]

WESTERN MGMT ZONE	OCTOBER 2002	NOVEMBER 2002†	JANUARY 2003	FEBRUARY 2003	MARCH 2003	MAY 2003
Outside park (zone 2)	0	0	0	0	0	127[3]
IBMP zone 1	110	125	25	42	13	160[4]
North/West of 7 mile Bridge	244	155	0	16	46	458[5]
7 mile Bridge/Madison Junction	17	97	108	47	95	287[6]
Total	371	377	133	105	154	1,032[7]

†Numbers are an average of bison counted in management zones for flights conducted on November 5–6, 2002, and March 20 and 24, 2003.
*Calves not counted or attempted to be distinguished from adults during this flight.
[1]187 adults, 14 calves; [2]237 adults, 14 calves; [3]110 adults, 17 calves; [4]152 adults, 8 calves; [5]446 adults, 12 calves; [6]235 adults, 52 calves; [7]943 adults, 89 calves.

areas where bison were most likely to be found at the time. The data were analyzed using correction models that accounted for seasonal detection rates of bison. The late winter population estimate of 3,160 seemed low based on the number of known bison mortalities at the time. The true population was most likely near the upper 95% confidence limit (Table 3). Six hundred-forty calves were counted during summer, providing an index to annual production that survives to mid-summer (Table 4). The summer population was estimated at 4,250 individuals.

Remote vaccination.— The Interagency Bison Management Plan Record of Decision (2000) directed Yellowstone National Park to develop a safe and effective delivery system for vaccinating wild, free-ranging bison. Study and public disclosure of environmental consequences must be completed before field implementation of a remote vaccination program can begin, and numerous projects have focused on gathering information to complete the necessary environmental planning. Several existing vaccine delivery mechanisms have been evaluated by the Greater Yellowstone Interagency Brucellosis Committee. Options include the use of darts, biobullets, oral vaccine, and DNA vaccines.

Approach study.— At this time, the most viable delivery system for remote vaccination of the Yellowstone bison is the use of darts and biobullets. However, some limitations for these options exist. Each target animal must be located, identified, and approached to a distance close enough to effectively delivery the vaccine. To determine whether this could be achieved, BEMO staff approached bison groups on foot, snowmobile, wheeled vehicle, and horseback in all areas of the park. Field crews simulated the noise of vaccine delivery by firing a .22 starter pistol (using blanks), and using a peacock call as a control. After April 5, 2002, the peacock call was discontinued, and dry-firing (firing the pistol without a blank in it) the starter pistol was used as a control instead. A total of 135 approaches were conducted prior to April 5, with 79% of the groups approached exhibiting no response regardless of the method of approach when approached from less than 40 meters away. Eighty-seven percent of the groups showed no response when approached from between 40–70 meters away. After April 5, 102 approaches were conducted. The percentage of individual animals exhibiting no response to approaches and firing of the .22 pistol was 96% when blanks were shot and 97% when dry-fired. One hundred percent of horse approaches in Hayden Valley were successful in approaching to 40 meters, compared to only 57% of horse approaches on the northern range. Wheeled vehicle approaches were most successful (87%) at approaching to within 40 meters in the Madison/Firehole River drainages, followed

Table 3. Population estimates based on park-wide aerial counts.

	LATE WINTER	SUMMER
Population estimate	3,160	4,250
Upper 95% confidence limit	3,600	4,400
Lower 95% confidence limit	3,070	4,230

Table 4. Actual number of bison observed by geographical area in winter versus summer population estimation counts, 2003.

	MARCH 20, 2003*	MARCH 24, 2002*	JULY 10, 2003	AUGUST 8, 2003	AUGUST 28, 2003*
Northern Range	978	1,044	803 *(681 adults, 122 calves)*	568 *(469 adults, 99 calves)*	781
Pelican Valley	198	188	158 *(155 adults, 3 calves)*	455 *(390 adults, 65 calves)*	845
Mary Mountain	1,837	1,771	2,817 *(2,383 adults, 434 calves)*	2,788 *(2,312 adults, 476 calves)*	2,569
Total	3,013	3,003	3,778 *(3,219 adults, 559 calves)*	3,811 *(3,171 adults, 640 calves)*	4,195

*Calves not counted or attempted to be distinguished from adults during this flight.

by the Hayden Valley–Lake and Mammoth–Norris areas, both showing a 76% success rate. Northern range wheeled vehicle approaches were successful within 40 meters 65% of the time. Overall, the success of approaching bison and delivering mock vaccinations with a variety of noise stimuli was successful. Further study needs to be done to determine the percentage of vaccine-eligible animals that can be successfully mock-vaccinated in these groups.

Mary Mountain study.— The seasonal migration of bison from high elevation plateaus inside the park to lower elevation winter range facilitates remote vaccination. The Mary Mountain patrol cabin is located along a significant migratory path utilized by bison traveling between winter and summer range in Yellowstone National Park. With approximately 54% of the park's bison herd traveling this route between May and July each year, the cabin provides an excellent site for delivering a vaccine using a pneumatic rifle and biobullet. Bison migration was monitored between May 5 and June 26, and mock vaccination trials were conducted on target animals defined as yearling bison to observe animal behavior in response to the noise of a simulated vaccine delivery.

Of an estimated 1,950 animals traveling east into Hayden Valley, 1,278 were observed. The age and sex structure of migrating bison consisted of 23% bulls, 47% cows, 10% calves, and 20% yearlings. Bison moved either in bachelor or mixed groups. Thirty-three bachelor groups were observed traveling east, ranging in size from 1 to 7. Nineteen mixed groups were observed moving east, widely ranging in size from 2 to 256 individuals.

The vaccination zone was defined as the area near the patrol cabin where a staff member could safely fire the remote delivery equipment at a target bison less than 30 meters from the shooter. A .22-caliber starter pistol was used to simulate the noise of the remote delivery equipment.

Bison approaching the vaccination zone exhibited predictable behavior. The lead animal, usually a cow, frequently stopped and looked in the direction of the cabin, possibly assessing the threat posed by the human-occupied area. After the pause, the animal typically exhibited heightened vigilance while entering the target zone. Examples included posturing, staring, and changes in gait. After the noise of a shot was heard by the group, vigilance behaviors, as well as gait, typically increased. Animals in single file sometimes crowded together two and three abreast. This was problematic, as yearlings occasionally moved behind other animals, which would make them difficult to target for vaccination purposes. However, 37% of the yearling animals walked through the area within 30 meters, making them feasible targets for vaccination. Approximately 80% of the yearlings presented a clear target hip, but about half were moving through the area at faster than a walking pace.

Other possible areas.— BEMO staff have identified and described 21 locations where topographic features create potentially favorable conditions for remote vaccination of free-ranging bison. These sites have been selected because they provide for human safety and concealment, and are along recognized bison travel routes.

Ballistics consortium.— This consortium met twice in FY03—once in January in Fort Collins, Colorado, and again in August in Yellowstone. This consortium partnership has spearheaded a new method for encapsulating vaccine for remote delivery in a bio-absorbable bullet, and has provided a forum for review of the best available technologies for remote delivery of vaccine to free-ranging bison throughout YNP. The National Park Service's wildlife veterinarian continues to co-chair this group. The consortium evaluated the management studies conducted at Yellowstone and at Colorado State University, and has agreed in concept that the remote delivery strategy proposed by the park is feasible for implementation.

Protocol, implementation, and field evaluation of remotely-administered ballistics.— A project was conducted to provide detailed information about the "target area" of a bison calf—the location most suitable for remote vaccine delivery—and the wound site characteristics for such a delivery. A protocol was developed in partnership with Wildlife Health Associates, and implemented at the private Red Rock Ranch near Dillon, Montana, where bison were purchased. The field test evaluated one pneumatic rifle system delivering a bio-absorbable vaccine via an encapsulated bullet at 20 meters distance. Twenty bison calves received a placebo vaccine remotely delivered by the pneumatic delivery system. Ballistic Technologies, Inc., provided the placebo vaccines, the delivery equipment, and a technician,

Table 5. Field classification of bison on two separate winter range areas, February 2003.

	BULLS	COWS	CALVES	YEARLING BULLS	YEARLING COWS	UNKNOWN YEARLINGS	UNKNOWN	TOTAL # CLASSIFIED
Northern Range	31.4%	36.4%	12%	4.5%	4.5%	2.3%	8.7%	349
Central Herd	17.6%	41%	18.8%	7.2%	7.5%	0.8%	7%	1,602

and staff from Montana State University and Turner Enterprises reviewed the study plan. The shoulder and thigh proved to be the two best locations for targets, measuring 14 and 24 cm in width, respectively. Penetration of the biobullets was deeper than necessary, but suitable for effective delivery of the vaccine. The degree of acute injury associated with biobullet implants was insignificant. These results are consistent with findings from elk and livestock studies conducted elsewhere.

Biobullet accuracy.— BEMO staff have been investigating a remote delivery system comprised of a compressed air rifle that shoots a biodegradable bullet capable of carrying a biological payload. Because the system was designed for distances of 10–30 feet or less, and in YNP it was determined that distances of 10–40 meters or further would be required to successfully deliver a brucellosis vaccine to wild bison, BEMO personnel developed a study to determine the accuracy of the bullet and delivery systems at distances that more closely reflect the reality of vaccinating wild bison in Yellowstone. Studies were conducted at 20, 10, and 30 meters. At 20 meters, three different employees shot the air rifle from a regular standing position, and a fourth shot an air rifle secured in a vise. Two different delivery systems were tested; the rifles were attached to an air regulator that delivered the payload at 1200psi, and one that delivered it at 1500psi. Two different bullet types were tested at 20 meters—a standard short bullet and a standard long bullet. There was no significant difference between the three shooters and the vise ($p>0.10$). There was a significant difference between the bullet types, with the standard long bullet being more accurate than the standard short bullet ($p<0.001$). The 1200psi system was significantly more accurate than the 1500psi system ($p<0.001$).

From 10 meters, two shooters tested the 1200psi regulator with the standard short and standard long bullets. There was no significant difference between shooters ($p>0.50$). A significant difference was noted between bullet types, with the standard long bullet being slightly more accurate than the standard short bullet ($p<0.05$).

At 30 meters, the same two shooters were used, as were the 1200psi and 1500psi systems. Bullets tested were the standard long and a long bullet containing a tungsten alloy for added weight. There was no significant difference between shooters ($p>0.10$). A significant difference between bullet types was observed, with the long tungsten-alloy bullet being more accurate than the standard long bullet ($p<0.001$). The 1200psi system was significantly more accurate than the 1500psi system ($p<0.001$). A shooter/bullet interaction was observed between one of the shooters and the long tungsten-alloy bullet type. This individual was less accurate than the other shooter/bullet combinations, but only with the metallic bullet ($p<0.05$). A significant bullet/pressure difference was also noted. The 1200psi system was more accurate than the 1500psi system when shooting the standard long bullet ($p<0.001$). From this study, it is recommended that the 1200psi system be used to deliver vaccine to targeted bison for distances up to 30 meters away.

Vaccine encapsulation.— This project was conducted in cooperation with Colorado State University's Department of Chemistry. Technology has been developed to encapsulate vaccine agents into bio-degradable, 6mm, bullet-shaped projectiles (biobullets). However, numerous technical challenges and necessary improvements remain. The purpose of this project is to evaluate the potential alternatives for encapsulation of live vaccine using short exposure to ultraviolet light to polymerize the vaccine solution in a polyethelene glycol (PEG) gel form. The project will also determine the viability of the vaccine after encapsulation. Photopolymerizable PEG has long been used to encapsulate proteins, DNA, and living mammalian cells. Under short UV exposure, little toxicity is seen with mammalian cell preparations.

Hydrated PEG gels are clear and soft. Dessicated gel slices are drastically reduced in size, and become hard, plastic-like, and translucent. Rehydration is rapid from the dried state. In this study, the PEG gel

formulation was developed, and a surrogate *brucella* bacteria *(Pseudomonas aeruginosa)* was successfully encapsulated. Rehydration of the encapsulated bacteria resulted in a loss of less than 10% of the original quantity of bacteria encapsulated. With the concept now proven, future work will focus on the feasibility of the *Brucella abortus* vaccine RB51 showing similar survivorship results following rehydration.

Bison demographics.

Winter.— A winter classification was conducted in February. A sample of 1,951 bison was classified to age and sex categories from the central and northern range areas combined. Approximately 90% of all animals observed were classified to a specific age or sex category (Table 5). Adult male bison comprised a significantly higher proportion of the northern range subpopulation. A lower proportion of calves and yearlings was observed on the northern range. The number of calves per 100 adult cows was 33 on the northern range and 45 in Hayden Valley.

Summer.— A summer classification was conducted in July and August. Field crews traveled throughout bison habitat via foot, horseback, and vehicle in the northern range, Hayden Valley, and Pelican Valley. Bison were observed and classified into sex and age (calf, yearling, adult) groups. In the summer efforts, BEMO crews classified more than 80% of the population, compared to around 50% in previous surveys. The number of animals identified as either unknown age or unknown sex was less than 6% in all three field locations (Table 6). Adult bulls comprised a higher percentage of the subpopulation on the northern range than in the central portion of the park. The number of calves per 100 adult cows was 49 on the northern range and 32 in Hayden Valley.

To quantify observer error, a strategy was initiated in which multiple independent classifications of the same groups were completed. Preliminary results suggest that there is greater error in distinguishing between young bulls and adult cows than between yearling animals and adult cows. Because of their small body size, it is often difficult to distinguish calves from amongst many other large animals.

Remote tracking. During late winter and spring 2002, eighteen seronegative (tested negative for brucellosis antibodies in the blood) cows were released from the capture facility near West Yellowstone and fitted with VHF transmitting collars. Two animals were recaptured in October to validate pregnancy and disease status, as no calves were ever located with either of these bison. Each animal tested positive for brucellosis antibodies, and it was suspected that pregnancies were aborted. The transmitting collars were removed.

The remaining bison with transmitting units provided valuable information about group movements throughout the park. In March, two animals were shipped to slaughter as part of a group of bison that left the park along the north boundary. Both animals spent the winter on the northern range between Gardiner and Norris Geyser Basin. One other animal also spent the winter on the northern range. Thus, 20% of this sample of bison shifted their win-

Table 6. Field classification of bison in three locations, summer 2003.

	%BULLS	%COWS	%CALVES	%YEARLING BULLS	%YEARLING COWS	%UNKNOWN YEARLINGS	%UNKNOWN	
	TOTAL #	*TOTAL #*	*TOTAL #*	*TOTAL #*	*TOTAL #*	*TOTAL #*	*TOTAL #*	*TOTAL*
Northern Range 1	40.2	38.1	9.8	4.9	2.6	.6	3.8	
	189	***179***	***46***	***23***	***12***	***3***	***18***	***470***
Northern Range 2	27.3	41.8	20.3	2	2.8	.9	5	
	148	***227***	***110***	***11***	***15***	***5***	***27***	***543***
Hayden Valley 1	20	48.1	16.5	5	8	.3	201	
	603	***1,450***	***498***	***150***	***241***	***9***	***62***	***3,013***
Hayden Valley 2	26.3	45.8	14.1	5	6.6	.6	1.5	
	588	***1,023***	***314***	***112***	***148***	***14***	***33***	***2,232***
Pelican Valley (ground)	100	0	0	0	0	0	0	
	65	***0***	***0***	***0***	***0***	***0***	***0***	***65***
Pelican Valley (flight)	100	0	0	0	0	0	0	
	67	***0***	***0***	***0***	***0***	***0***	***0***	***67***

ter range to the northern range from the previous year, when they wintered in the Madison/Firehole watershed. Only one of the bison from this sample spent the summer time as far east as Pelican Valley.

Lynx

In 2000, the U.S. Fish and Wildlife Service listed the Canada lynx as a threatened species in the contiguous 48 states. After completing design work from 1999–2000, Yellowstone staff initiated a three-year survey project in 2001 to document lynx presence and distribution in the park. The survey included three summer field seasons, during which lynx project staff used the U.S. Forest Service lynx detection protocol (hair snares and laboratory-based DNA extraction). Work was focused primarily on the park's east side, but opportunistically in other parts of Yellowstone as well. To date, lynx project staff have collected 516 total hair, bone, and fecal samples along 151 transects (typically five hair snare stations per transect), detecting one female lynx on the east side of the park in summer 2001.

The survey also included three winters of ski- and snowmobile-based snow tracking efforts in habitats dominated by mid-aged (>50 years), mature, and old-aged stands of lodgepole pine, spruce, and subalpine fir widely distributed in the park. To date, 243 different transects totaling 1,388 miles in length and ranging from 1–32 miles have been completed. Surveys have been conducted mostly in soft snow that readily showed fresh animal tracks. One possible, two probable, and one definite lynx track have been detected, including a female lynx and her kitten detected during snow tracking on the east side of the park in winter 2003. Hair and fecal samples confirmed the presence of a male lynx, apparently the kitten. This detection of the female lynx with kitten was unique in that it was the only confirmed observation of lynx reproduction in park history. Nearly all other Yellowstone carnivores have also been detected, including tracks of wolverines (three observations), cougars, bobcats, and river otter. No fishers have been detected by any method.

During winter 2004, project staff will focus a fourth survey on the east side of the park where the family was documented, attempting to confirm the residence of the adult female and/or her kitten and learn about their travel patterns and food habits.

Ungulates

Elk. The estimated minimum number of elk residing on the park's northern range during 2003 was 9,215, based on the number of animals counted from fixed-wing aircraft on December 24, 2002. Poor counting conditions likely contributed to this relatively low trend count compared to the 11,969 elk counted during December 2001. A lack of snow cover created a brown background on the landscape, making elk difficult to detect. Also, elk were widely dispersed at higher elevations owing to the lack of snowpack and mild winter. However, the long-term trend in counts of northern Yellowstone elk suggests that the population has decreased since 1988. Factors contributing to this overall decreasing trend likely include predation and human harvest, drought-related effects on pregnancy and calf survival, and periodic substantial winter-kill resulting from severe snowpack.

A late winter elk classification flight was flown via helicopter on the northern range on March 24, 2003. A total of 4,200 elk were classified, with 12 calves and 22 total bulls observed per 100 cows. The estimated ratio of 12 calves per 100 cows is similar to the late winter ratio during 2002 (14 calves per 100 cows), but less than the range of 22 to 34 calves per 100 cows observed during the previous six years. This low calf–cow ratio suggests that recruitment into the northern range elk population was relatively low for this cohort. The causes of this year's low recruitment are most likely predation and drought-related effects on maternal condition and calf survival. This is the second consecutive year of low recruitment for northern Yellowstone elk. The low recruitment noted during these two years will not necessarily have a substantial, long-term effect on overall reproductive rates or population abundance, because the majority of prime-aged females (3–17 years old) produce calves. This "summing" effect of more than 15 cohorts producing calves during a given year should minimize the effects of low calf survival in one or two cohorts. However, continued low recruitment in subsequent years would almost certainly result in a significant decrease in the population growth rate.

The estimated number of non-migratory elk residing in the west-central portion of the park during spring 2003 was 384 $\pm$ 72. This estimate was

derived from a series of 10 daily mark–recapture experiments conducted by biologists from Montana State University along the road system during April. This estimate is lower than the average count of 506 elk (range 440–612 elk, n = 9) for this population during 1965–1988. A ratio of approximately 4 calves per 100 cows was observed by biologists from Montana State University during the April 2003 surveys. Wide annual variability in recruitment (<1–38 calves per 100 cows) has been observed in this population since 1992, due to variations in snowpack and predation pressure.

In 1999, Yellowstone National Park initiated a broad monitoring and collaborative research program to evaluate the consequences of wolf restoration on the park ecosystem. There are four integrated components to the project: 1) wolf functional and numerical responses; 2) elk habitat selection and population demographics; 3) elk and wolf behavioral adjustments; and 4) vegetation responses to changes in elk densities. Radio telemetry is used to monitor the survival, reproduction, movements, and resource selection of elk during these studies. Since 1999, biologists have obtained more than 4,320 locations from 117 adult female elk with VHF radio collars that utilized the northern range during winter. Thirty-six elk have been fitted with GPS radio collars, from which more than 14,860 locations have been acquired. There have been 38 deaths of radio-collared elk, including 11 elk legally harvested by hunters outside the park, 16 elk killed by predators (12 killed by wolves, 3 by mountain lions, 1 by bear), 3 winter-killed elk, 1 capture-related death, and 7 elk that died due to unknown causes. Currently, 50 adult female elk on the northern range are equipped with functional radio collars (40 VHF, 10 GPS).

In 1991, YNP partnered with Montana State University to investigate the demographics of elk in the west-central portion of the park. This investigation has continued for 12 consecutive winters, and was expanded in scope to include predator–prey interactions when wolves established a territory in this area of the park during 1998. Ungulate demographic data collected during this effort includes multiple annual population estimates, indices of annual pregnancy rates and recruitment, and estimates of survival and cause-specific mortality. To date, population distribution and individual movement databases include approximately 11,760 locations from 92 adult female elk with VHF radio collars, 7,500 locations from 6 elk with GPS radio collars, 720 locations of radio-collared wolves, 1,873 kilometers of travel vectors for wolves obtained from snow tracking, and the identification of 395 wolf kills. In conjunction with this effort, researchers from California State University–Monterey Bay initiated an ambitious study of snowpack characteristics, distribution, and dynamics two years ago. This effort has produced databases including 1,600 snow cores, temperature and ram-hardness profiles at 19 snow pits, and season-long continuous snowpack thermal gradient measurements from nine sites in varying terrain.

During May 2003, the Yellowstone Center for Resources, U.S. Geological Survey, and University of Minnesota initiated a three-year study (FY 2003–2005) of mortality in northern Yellowstone elk calves. The primary objectives of the study were to: 1) estimate the relative causes and timing of calf deaths; 2) estimate calf survival rates; and 3) evaluate factors that may predispose calves to death. During May–June 2003, a total of 51 calves $\leq$6 days old were captured and fit with ear tag transmitters. These calves were subsequently monitored on approximately a daily basis. During May–September 2003, 34 instrumented calves died (31 predation, 3 other causes) and one transmitter ceased functioning. Preliminary determinations of causes of death for instrumented calves were 19 killed by bears, 5 killed by wolves, 3 killed by coyotes, 2 killed by either wolves or bears, 1 killed by a mountain lion, 1 killed by a wolverine, and 3 non-predation deaths due to unknown causes. Monitoring of instrumented calves will continue through winter 2004, and the next capture is scheduled for May–June 2004.

During winter–spring 2003, the Yellowstone Center for Resources and Montana State University completed a collaborative analysis of the initial consequences of wolf recovery on the world-renowned, migratory population of northern Yellowstone elk by: 1) coalescing and integrating information on their abundance, classification (age and sex), and vital rates; 2) evaluating the adequacy and reliability of these data as they are currently collected; 3) evaluating trends in abundance and vital rates over time, including pre- and post-wolf restoration periods; and 4) evaluating the relative influence of human harvest and wolf removals on their demographics.

Though these analyses were, by necessity, a simplification, results suggested that elk abundance will continue to decrease in the near future until levels of harvest by humans and/or predators decrease sufficiently. This conclusion should be viewed with caution due to several oversimplifications and uncertainties about parameter values used in the analyses. Also, it is anticipated that neither hunter harvest nor wolf predation will remain at current levels into the future due to a variety of biological, political, and societal processes. For example, during summer 2003, Montana Fish, Wildlife and Parks reduced the number of late season antlerless permits for northern Yellowstone elk from 2,080 during 2003 to 1,400 during 2004. Thus, actual trends in elk and wolf populations may differ substantially from predictions of the models.

YCR wildlife biologist P.J. White and University of Minnesota Ph.D. candidate Shannon Barber tag an elk calf.

Mule deer. An early winter helicopter classification survey of mule deer on the Gardner basin winter range was not conducted during 2003, due to poor flying conditions and lack of pilot availability in December and early January. Since 1990, ratios of bucks to does in the Gardner basin have ranged between 7–24 bucks per 100 does, with relatively high buck ratios (17–24 bucks per 100 does) in recent years.

Biologists from Montana Fish, Wildlife, and Parks observed 2,023 mule deer during a helicopter count on the Gardner basin winter range (i.e., Yankee Jim Canyon to Mammoth) during April 28 and May 1–2, 2003. This was the second highest count of mule deer since the relatively severe winter of 1996–1997. A total of 702 of these animals were classified by sex and age. Based on this sample, there was a ratio of 44 fawns per 100 adults. During 1986–2002, spring recruitment ranged between 14–57 fawns per 100 adults.

Pronghorn. The estimated minimum number of pronghorn residing on the northern range during 2003 was 246, based on the number of animals counted during simultaneous fixed-wing aircraft and ground surveys on March 25, 2003. This count is similar to annual counts obtained during 1995–2002 (range = 204–242 pronghorn), suggesting that the abundance of the Yellowstone pronghorn population has remained approximately constant during this time period.

The annual summer classification of Yellowstone pronghorn was conducted on July 14, 2003, using a fixed-wing airplane and a single observer. One hundred-thirteen pronghorn were classified (73 adult females, 11 adult males, and 29 fawns) in 19 groups. Observed sex and age ratios for these pronghorn were 40 fawns per 100 adult females, and 15 adult males per 100 adult females. These results suggest that fawn survival and recruitment may be somewhat higher this year than during the previous five years. Thirty-five percent of the observed adult pronghorn were non-migratory residents of the Gardner basin, whereas 65% of the adults were migratory and summered in areas east of Mammoth. Likewise, 65% of radio-collared adult female pronghorn were migratory during 1999–2001. More fawns were observed in

migratory groups (n = 22 fawns) than non-migratory groups (n = 7). However, the ratio of fawns per 100 adult females was similar between non-migratory (32 fawns per 100 females) and migratory (43 fawns per 100 females) groups.

During 1999–2002, a cooperative study of Yellowstone pronghorn fecundity, fawn mortality, and resource selection was conducted by biologists from Montana State University, the University of Idaho, and the Yellowstone Center for Resources. Radio telemetry data were collected from 34 adult does during this period. During 2003, YCR staff continued monitoring remaining radio-collared pronghorn (n ~ 12) on a weekly basis to build upon baseline information regarding vital rates, distribution, and movements of Yellowstone pronghorn collected during 1999–2002. Preliminary results of these studies suggest that annual adult female survival was relatively low (0.85), and recruitment of pronghorn fawns was poor (0.04 to 0.61 fawn per female), during 1999–2002.

A proposal by the Federal Highway Administration to realign the North Entrance road between the Gardner River and base of Mount Everts led YCR staff to start focusing on pronghorn migratory movements. Proposed alternative alignments pass through or near areas in the vicinity of Mount Everts that may be important for Yellowstone pronghorn prior to or during migratory movements. Data collected to date indicate that migratory pronghorn "stage" on the flats and lower elevation slopes at the northwest end of Mount Everts for approximately 1–2 weeks prior to their migratory movements. The majority of spring migratory movements occur during April and early May, while autumn movements occur during August through early November. Pronghorn appear to use at least three migratory routes over Mount Everts to travel to and from their summer range. Migratory pronghorn summer in widely dispersed areas, including the Blacktail Deer Plateau, Oxbow Creek slopes, Hellroaring slopes, Specimen Ridge, and Lamar Valley.

Bighorn sheep. Biologists from Montana Fish, Wildlife and Parks observed 185 bighorn sheep (90 ewes, 29 lambs, 66 rams) during a helicopter count on the Gardner basin winter range (i.e., Yankee Jim Canyon to Mammoth) during April 28 and May 1–2, 2003. Since 1995, the total count has ranged between 134–229 sheep (mean = 183 sheep). Estimates of recruitment and adult sex ratios during 2003 were 32 lambs per 100 ewes and 73 rams per 100 ewes. Lamb recruitment was similar to the previous four years and higher than the 7–8 lambs per 100 ewes observed during 1997 and 1998. While total sheep numbers within and outside Yellowstone National Park appear to have decreased since the mid-1990s, recruitment was relatively high (50 lambs per 100 ewes) during 2003 for the portion of the population within the park.

Mountain goats. On September 15 and 19, 2003, aerial surveys for mountain goats were conducted in and adjacent to Yellowstone National Park. One hundred-twenty mountain goats, including 32 kids (<1-year-old animals) and 88 adults, were observed during the 10-hour survey. Mountain goats were widely distributed, with observations on Cinnabar Mountain, upper Tom Miner drainage, Meldrum Mountain, Sheep Mountain, Bighorn Peak, Ramshorn Peak, Sepulcher Mountain, Electric Peak, Quadrant Mountain/Bannock Peak, Dome Mountain, Mount Holmes, Mount Hornaday, Barronette Peak, Cutoff Mountain, Wolverine Peak/Mount Abundance, Sunset Peak, Mineral Peak, Abiathar Peak/Amphitheater Mountain, and The Thunderer/Mount Norris. No goats were observed in the Washburn Range or south of The Thunderer along the eastern park boundary to Top Notch Peak.

The distribution and composition (36 kids per 100 adults) of observed mountain goats during 2003 were similar to results from surveys conducted in or near the park during 1997–2002. Mountain goats have clearly established a breeding population in the park, and their relative abundance appears to be increasing. However, survey results suggest that the sustained colonization of suitable habitats south of The Thunderer and along the eastern park boundary has not yet occurred, despite occupation of adjacent areas outside the park. Based on surveys during 1997–2003, there are probably 125–175 goats in Yellowstone National Park.

The recent colonization and relatively rapid increase in abundance and distribution of descendents of introduced mountain goats in Yellowstone National Park raises important policy and management questions. Thus, habitat and population monitoring of mountain goats to evaluate their potential ecological effects will continue, as will collaboration

and consultation with other federal and state agencies. A management plan for mountain goats will be started and developed.

Wolves

Population monitoring and management.

Population status.— At the end of December 2003, at least 174 wolves in 14 packs occupied Yellowstone National Park (Figure 1). This represents a population increase of about 17% from 2002, when 148 wolves in 14 packs lived in the park. The current status of one pack that was present in May 2003 (Buffalo Fork pack, counted as a 15th pack) is unknown, because that pack's only radio-collared wolf (#105F) was lost. The pack consisted of at least four wolves in May, and it denned this spring. Field work in the area where they resided revealed tracks, but it could not be determined if the tracks were from the remnant Buffalo Fork pack or the neighboring Rose Creek pack.

Eight of these packs (96 wolves) reside on the northern range and seven packs (78 wolves) live throughout the rest of the park. Pack sizes ranged from 5 (Gibbon group) to 20 (Swan Lake pack), and averaged 11.3. Pack size was not different between the northern range and the rest of the park.

One new pack formed and one was lost in 2003. The Gibbon group formed late in 2003, probably from wolves dispersing out of the Nez Perce and Cougar Creek packs, and was not considered a breeding pair. The Tower pack was lost when male #208 died from natural causes (exact cause is unknown). This pack was only two individuals, and the fate of his uncollared mate is unknown.

With only one new pack, wolf distribution and movements were largely the same for 2003. Most packs on the northern range showed typical movements: low elevation in winter and for denning, and high elevation for foraging in summer. Wolf packs elsewhere in the park, except for the Cougar Creek pack, engaged in extraterritorial forays outside the park in search of prey. The Nez Perce pack, for example, visited the National Elk Refuge in January, and the Yellowstone Delta pack spent significant periods of time in the Teton wilderness. Mollie's pack moved for short periods of time into the North Fork of the Shoshone River. The Bechler pack used Targhee National Forest and the Bechler area through the winter. They were probably able to use this deep-snow area of the park because it was a mild winter. This pattern of use is not expected to continue when more normal winters for that area return.

Of these 15 packs, 13 count toward the breeding pair objective for the Yellowstone Recovery Area. To count toward the breeding pair objective, a pack must have two pups. It is unknown if the Gibbon group had pups, and the status of the Buffalo Fork pack is unknown.

Reproduction.— At least 75 pups were born and 59 survived in 15 wolf packs in 2003. At least 16 and possibly 17 total litters were born; the Druid Peak pack had at least two and possibly three litters of pups. Average number of pups born per pack was 5, and ranged from 2 to 13 (at least two litters). Survival varied by pack. The Geode Creek pack had eight pups, but only two survived, while the Leopold pack had eight as well, and all of them survived. Other

Table 1. Wolf mortalities, 2003.

DATE OF DEATH	WOLF #	SEX	PACK	AGE CLASS	SOCIAL CLASS	CAUSE OF DEATH
12-31-02	002M	male	disperser from Leopold	old adult	alpha	intraspecific
1-21-03	211M	male	disperser from Leopold	adult	unknown	intraspecific
2-4-03	309F	female	unknown; found in Old Faithful area	yearling	unknown	intraspecific
3-7-03	175F	female	Mollie's	adult	alpha	interspecific
3-8-03	296M	male	Agate Creek	adult	unknown	disease
4-12-03	208M	male	Tower	adult	alpha	natural unknown
4-21-03	259F	female	Leopold	adult	alpha	natural unknown
6-6-03	105F	female	Buffalo Fork	adult	alpha	intraspecific
6-17-03	251F	female	Agate, but possibly dispersed	adult	alpha	interspecific
7-27-03	346?	unknown	Druid Peak	pup	subordinate	natural unknown
7-29-03	260F	female	disperser from Rose Creek II	adult	unknown	natural unknown
8-7-03	220F	female	Leopold	adult	possible breeder	interspecific
9-2-03	207M	male	Rose Creek II	adult	possible alpha	natural unknown

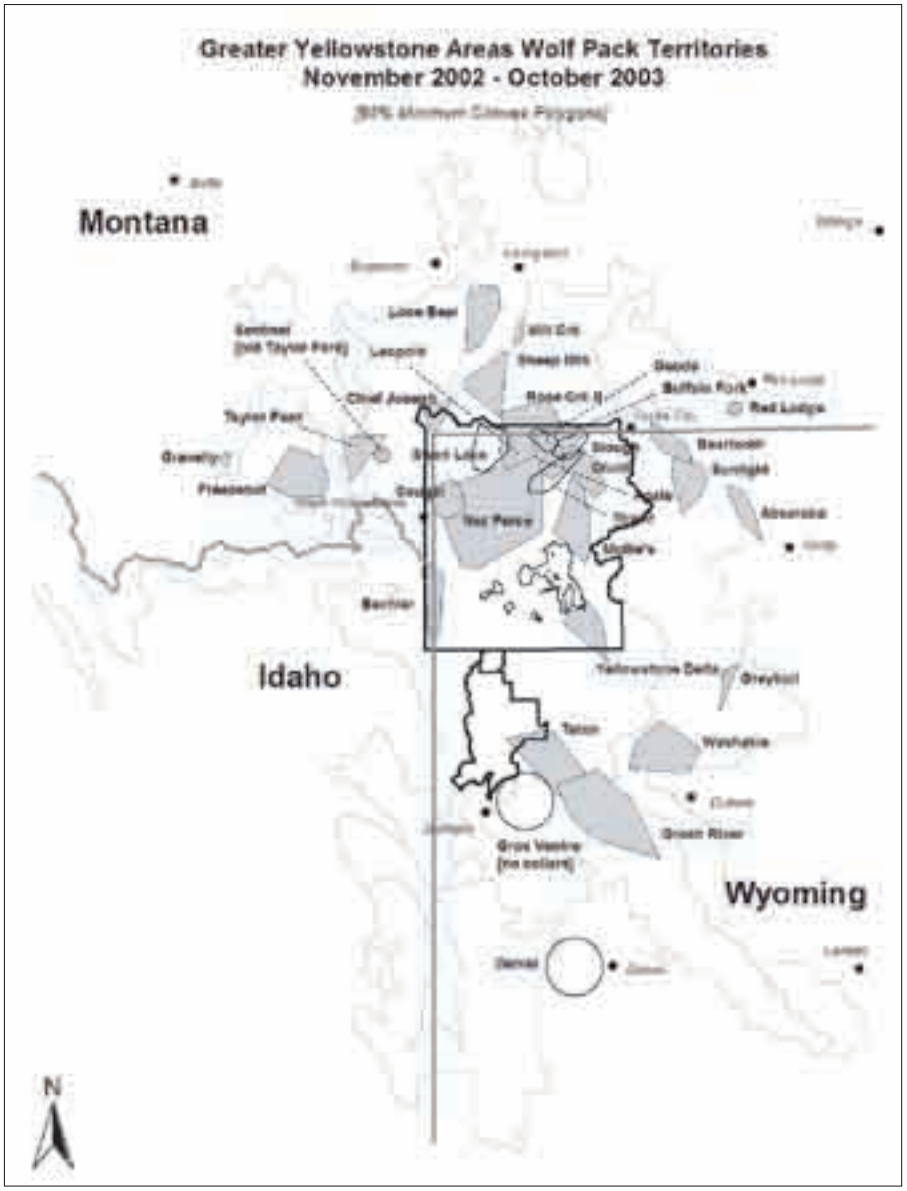


Figure 1. Greater Yellowstone Area wolf pack territories, 2003.

packs with good pup survival were Druid Peak, Slough Creek, Swan Lake, and Yellowstone Delta. Packs with poor survival were #302's group (gone at the end of 2003) and Agate Creek. The remaining packs either had moderate or unknown pup survival.

Twelve wolf dens were visited this summer to measure den characteristics and collect scats for summer food habits. Not counting packs denning for the first time, 7 (64%) of 11 packs reused old den sites.

Mortalities.— Thirteen wolves (12 adults and 1 pup) were known to have died in YNP during FY 2003 (Table 1), including seven females, five males, and one of unknown sex (due to partial decay). All the wolves that died within YNP died of natural causes.

One of the prey-caused deaths was observed in Pelican Valley in March. A battle with a bull bison killed one of the Mollie's pack wolves and injured two others; the bison kicked one wolf, throwing it 10–15 m in the air, and hooked another with its horn, also launching the wolf airborne for several meters. The wolves eventually killed the bison, taking all of one day to do it.

One wolf from the Agate Creek pack died from apparent disease. Although staff were able to retrieve the carcass from the field the day after discovering the mortality, disease analysis on the carcass was

inconclusive because of slight decay of the tissues. Disease experts at Montana Fish, Wildlife and Parks' lab in Bozeman, Montana, excluded other causes of death, and other evidence from the necropsy was suggestive of death due to unknown disease. Prior to necropsy, a field trip of visiting veterinarians inspected the carcass externally, and also corroborated a disease cause of death based on bleeding from the anus and mouth.

Mange *(Sarcoptes scabei),* an infestation of a mite that burrows under the animal's skin leading to hair loss, has been reported for wolves living around but not in YNP. Wolves both east and north of YNP have been documented to have mange. Mange in wolves has not been documented in YNP.

Survival.— A park-led effort to determine annual survival of wolves in all three recovery areas of the northern Rocky Mountains is nearing completion. Average annual survival for a radio-collared wolf in the Yellowstone ecosystem is 80%. Pups had the lowest annual survival rate at 74%, followed by adults (>1 year old) at 80%, and yearlings at 83%. Annual survival for males and females for all age classes was 81% and 78%, respectively. Since reintroduction in 1995, annual survival ranged from a low of 62% in 1997 to a high of 90% in 1999.

Survival of wolves in the Idaho recovery area (79%) was approximately equal to the Yellowstone Recovery Area, whereas the northwest Montana recovery area had a significantly lower annual survival (56%).

Status of original reintroduced wolves.— Only two wolves from the original 31 reintroduced are still alive, both reintroduced in 1996. The last 1995 wolf to die was #2M, on December 31, 2002. He was killed by wolves in the Geode Creek pack after he lost his dominant (alpha) status in the Leopold pack and was traveling alone or with a few other wolves between wolf territories. He was eight years old when he died. Wolf #41F and #42F, both originally of the Druid Peak pack, are also still alive. Number 41 dispersed from the park and lives in Sunlight Basin, Wyoming. Number 42 is alpha female of the famous Druid Peak pack and is observed by thousands of wolf watchers each year in Lamar Valley. She is also eight years of age and formerly black; she is now completely gray.

Wolf–prey relationships. Wolf–prey relationships were documented by observing wolf predation directly and by recording the characteristics of wolf prey at kill sites. Wolf packs were monitored during two winter study sessions, 30-day periods in March and November–December during which wolves were intensively radio-tracked. The Leopold, Geode, and Druid Peak packs were monitored by two-person teams from the ground and from aircraft; the Swan Lake, Rose Creek, Agate Creek, Slough Creek, Buffalo Fork, Chief Joseph, Mollie's, Bechler, Nez Perce, Sheep Mountain, Tower, Cougar, and Yellowstone Delta packs were monitored from aircraft only. YNP staff recorded and entered into a database the behavioral interactions between wolves and prey, predation rates, the total time wolves fed on their kills, percent consumption of kills by wolves and scavengers, characteristics of wolf prey (e.g., nutritional condition), and characteristics of kill sites. In addition, similar data were collected opportunistically throughout the year during weekly monitoring flights and ground observations. The abundance and sex–age composition of elk within wolf pack territories were also estimated from the ground and from fixed-wing aircraft.

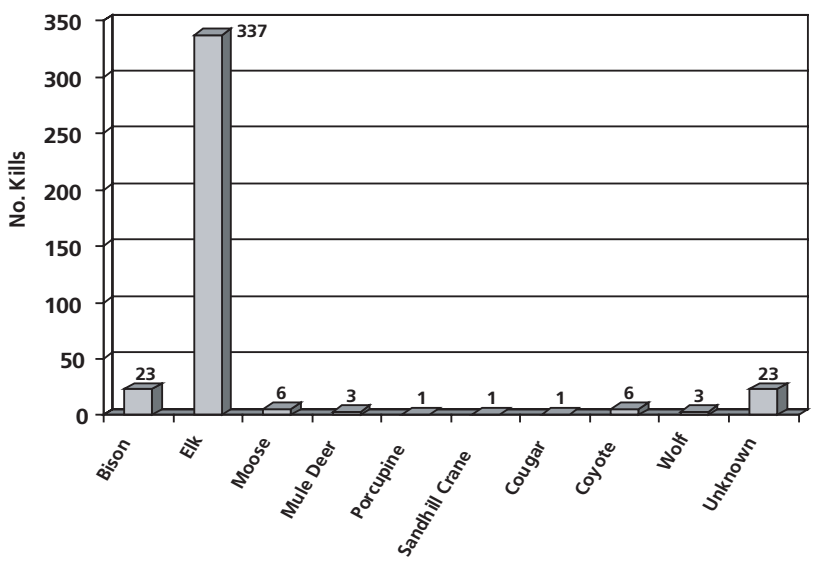


Figure 2. Composition of wolf kills, 2003.

Composition of wolf kills.— Project staff detected 116 definite, 249 probable, and 39 possible kills made by wolves in 2003, including 337 elk (83% of total), 23 bison, (6%), 6 moose (<2%), 3 deer (1%), 1 cougar (<1%), 6 coyotes (<2%), 3 wolves (1%), 1 porcupine (<1%), 1 sandhill crane (<1%), and 23 unknown prey (6%) (Figure 2). The composition of elk kills was 28% calves (0–12 months), 20% cows (1–9 years old), 9% old cows (≥10 years old), 26% bulls, and 17% elk of unknown sex and/or age. Bison kills included five calves (unknown sex), 11 cows, six bulls, and one unknown sex and age. During winter, wolves residing on the northern range killed an average of 1.8 elk per wolf per 30-day study period.

Winter studies.— During the 2003 March winter study (30 days), wolves were observed for 425 hours from the ground. The number of days wolf packs were located from the air ranged from zero (Chief Joseph, Yellowstone Delta, and Bechler) to 11 (Leopold, Geode, and Druid Peak). Sixty-three definite or probable wolf kills were detected, including 57 elk, 4 bison, 1 mule deer, and 1 moose. Among elk, 10 (18%) were calves, 15 (26%) were cows, 25 (44%) were bulls, 3 (5%) were of unknown sex adult, and 4 (7%) were of unknown sex and age. During the 2003 November–December winter study (30 days), wolves were observed for 317 hours from the ground. The number of days wolf packs were located from the air ranged from 0 (Yellowstone Delta and Rose Creek) to 10 (Leopold, Druid Peak, Geode Creek, Slough Creek, Agate Creek, and #302M's group). Fifty-seven definite, probable, or possible wolf kills were detected during the November–December 2003 winter study, including 50 elk, 1 coyote, 1 moose, 1 mule deer, 2 wolves, and 2 unknown prey. Among elk, 22 (44%) of the kills were calves, 6 (12%) were cows, 4 (8%) were old cows (10+ years), 12 (24%) were bulls, 1 (2%) kill was adult elk of unknown sex, and 5 (10%) kills were of unknown sex or age.

Summer studies.— Beginning in summer 2003, project staff began efforts to document summer predation patterns by wolves. Documenting the predatory habits of wolves in summer is problematic due to the lack of snow for tracking, increased nighttime activity of wolves, lack of pack cohesiveness, and smaller prey packages, leading to quick consumption and loss of evidence. Traditionally, the best data concerning wolf summer food habits have come from analysis of scat contents collected at den and rendezvous sites. In the summer of 2003, project staff collected a record 530 wolf scats from the Bechler, Druid Peak, Leopold, Geode, Nez Perce, Cougar Creek, Swan Lake, and Slough Creek wolf packs at their den and rendezvous areas. When analyzed, these samples will provide relative indices of prey selection and consumption patterns during the summer.

In addition, Wolf Project staff deployed four GPS (Global Positioning System) collars in January 2003 to enhance understanding of 1) seasonal predation patterns; 2) spatial and temporal interactions with other wolf packs and other carnivores; 3) movements with respect to dens during pup rearing season; and 4) territory size, use, and overlap (Figure 3). Because GPS collars provide more accurate and numerous data than traditional radio telemetry collars, and reduce reliance on aerial monitoring, the GPS collar program has been expanded. Some of these collars allow GPS location data to be remotely downloaded on a regular basis while still on the animal. Using spatial and temporal location analyses, probable kill sites can be identified from clustered points, which can then be investigated to determine if a wolf kill is present as well as what the species, age, and sex of the prey animal was. For example, through the use of summer field observations of wolf predation and downloadable GPS location data, seven kills made by the Druid Peak pack were documented for the month of June (two adult bull elk, two elk calves, and three unknown elk). Combining GPS collar technology with ground effort is expected to yield significant advances in understanding summer predation, and will therefore continue in 2004 with improved GPS collar technology and field protocol.

Scavenger studies.— An important aspect to trophic cascade research as it relates to wolf restoration is the effect on scavenger guilds in the Yellowstone ecosystem. Research on wolf and scavenger interactions has been conducted since 1998, through support from Canon, U.S.A., and the Yellowstone Center for Resources. This research, largely done in winter, has monitored how wolves influence the abundance and distribution of carrion, both spatially and temporally, as well as how they facilitate food acquisition by other carnivores. Although a great deal has been learned about the magnitude and relative importance of wolf-killed carcasses to the winter scavenger com-

munities, little is known about the impact on summer scavengers, both vertebrate and invertebrate. It is hoped that this focus on summer scavenging will offer a complete picture of the ecological relationship between wolves and scavengers relative to seasonal variation, abundance, and diversity. In summer 2003, project staff increased monitoring efforts on summer carcasses to document scavenger utilization and behavioral interactions between wolves and scavengers. Preliminary results indicate less use by vertebrate scavengers than is documented during winter, likely due to alternate food source availability. This would suggest an increase in biomass available for consumption by wolves; however, the impact of invertebrate scavengers is not known at this time. On several occasions, wolves have been documented scavenging on other predators' kills, suggesting that this may be a beneficial foraging strategy at times.

NPS/DOUG SMITH

Biologist Dan Stahler with a Slough Creek wolf during Wolf Project collaring operations.

A Spatial Analysis Center staffer records measurements made by a maintenance worker as part of the utility map creation process.

Part IV. Professional Support Programs

This section describes the work accomplished or coordinated by the following YCR staff who provide services for other YCR branches and other park divisions:

- **The Spatial Analysis Center,** responsible for the park's geographic information systems, global positioning systems, and other resource databases;
- **The Resource Information and Publications Team,** which produces publications and provides special programs on natural and cultural resource topics;
- **Research Support,** which oversees permitting for visiting and in-park researchers;
- **Benefits-Sharing EIS,** which provides for public dialogue on issues surrounding benefits-sharing as well as a means to evaluate potential environmental effects related to a set of alternative approaches to managing benefits-sharing when research involving biological specimens collected from NPS units yields commercially valuable results; and
- **Funding and Personnel Support** for the YCR Division.

Spatial Analysis Center

The Spatial Analysis Center (SAC) is home to the park's geographic information systems (GIS), global positioning systems (GPS), image analysis, soil information support, and a park resource database system. Its main business is the acquisition, analysis, organization, storage, and maintenance of data and the presentation of information relevant to Yellowstone National Park. The SAC's goals are to maintain an up-to-date GIS lab, provide GPS equipment and expertise, increase the GIS and GPS skill levels of park staff, acquire new

data and make it useful, provide information and technical support to park staff, and make information available to outside agencies and the public.

Projects

Thermal feature inventory. In FY03, a spatial inventory of thermal areas, including point locations collected with GPS units and converted into GIS layers, was continued for the sixth year. Data such as temperature, pH, and conductivity were collected and associated with each point location, along with a digital photograph of the feature. The SAC added 1,104 new features from Hot Springs Basin, Forest Springs, and the Bechler area, bringing the total number of sampled features in the database to over 7,800.

Thermophile inventory. This was the second year of inventorying the phylogenetic and physiological diversity of Yellowstone's thermal springs. Staff members collected two types of information: detailed data from 100 representative springs, and less detailed data from a larger number of satellite springs in the vicinity of the detailed sites. In FY03, staff collected samples from 49 detailed sites, where they identified full 16S rRNA gene sequences (~1500 chromosome base pairs per organism), analyzed water chemistry (pH, temperature, anions, cations, nutrients sulfur species, stable isotopes, dissolved oxygen, and dissolved organic carbon), and identified the geologic setting (rock type, alteration, and soil development). Staff also collected samples from 255 satellite sites. At these sites, pH, temperature, and location were recorded, and samples were collected to identify partial 16S rRNA gene sequences (~200 chromosome base pairs per organism). At the time of this report, the gene sequences for 91 satellite sites had been analyzed, and 40 more were in process. The analysis of the detailed sites is planned for this winter.

Utility maps. Currently, the locations of water and wastewater facilities are managed by employee memory or paper maps that date from 1968–1985. In some cases, the actual locations of the components (sewers, valves, etc.) are not known with good reliability. The objective of this project was to locate and document, with sub-meter accuracy, all of Yellowstone's water and wastewater facilities and components. The success of the project depends heavily on existing staff knowledge of true locations. New GIS layers were created using GPS, and will be managed and maintained within a GIS database. The new layers included manholes, sewer mains, cleanouts, lift stations, valves, water mains, and hydrants. Using the new data, staff can create up-to-date maps with accurate and reliable information. Areas completed include Old Faithful, Canyon, Grant, West Thumb, Lewis Lake, South Entrance, Madison, West Entrance, and Bechler. Areas partially done include Mammoth, Lake, Bridge Bay, and Fishing Bridge. The locations of approximately 750 manholes, 25 miles of sewer mains, 320 hydrants and 1,100 valves have been recorded as of November 2003.

Mining claims and oil and gas leases. Resource extraction in the areas surrounding the Greater Yellowstone Area Network (Yellowstone and Grand Teton national parks and Bighorn Canyon National Recreation Area) has the potential to negatively

Student Conservation Association intern Tim McIntyre takes pH and temperature readings from a hot spring for the thermal feature inventory, summer 2003.

impact the resources that each park is mandated to protect. This project documented the type and location of over 10,000 active mining (gravel extraction and hard rock mining) claims and leases, oil and gas leases, and geothermal leases within 20 miles of each park. Yellowstone has 3,900 sites within 20 miles of its borders. Most of the activity is concentrated north of Yellowstone or south of Bighorn Canyon. Until now, this information was not available to park managers. Extensive data mining efforts were necessary to determine where the best information was stored. Ultimately, data were obtained from the Land and Mineral Records Database (LR2000) from the Bureau of Land Management's Denver office. The data were then imported into Access, and a relational database was created. All pertinent data were imported into ArcGIS and joined to Public Land Survey System layers based on township, range, and section legal descriptions.

Fire maps and databases. SAC staff worked with the fire cache to create accurate fire perimeters and burn severity maps of all fires each year using imagery from LANDSAT satellites. In FY03, SAC staff provided daily maps of fire starts and fire perimeters, error-checked collected GIS fire data, and added daily fire map updates to the park's website. Staff also made many maps to assist in the planning of Wildland–Urban Interface projects. In addition, SAC staff documented the park's fire history (late 1800s to present) and modified the data to meet new servicewide standards.

Planning database. SAC staff continued to work on a database designed to make relevant resource and infrastructure information more accessible to people involved with project planning, compliance, and implementation. This involved the development of detailed GIS layers tied to a database of information about each developed area and road corridor. The information includes data about historic structures and other important cultural resource information, surficial and bedrock geology, soils, wetlands, important natural resources (e.g., threatened and endangered species, species of special concern, important or delicate habitats), existing infrastructure (roads, trails, and buildings), and other subjects of interest. An Intranet interface was developed in 2003, allowing users to query the database, identify potential resource impacts, and create maps. The interface also displays photographs, drawings, and other scanned documents that help clarify resource situations. Work on this project will continue in 2004.

Federal Highway Administration project support. Last year, the SAC continued to support projects associated with the Federal Highways program. This involved continuing to update databases for rare plants, archeology sites, and wetlands. In addition, SAC staff provided GPS support for mapping rare plant locations, delineating wetlands, and documenting archeological sites and historic structures. SAC staff acquired copies of older (pre-1990) data, and are incorporating it into the databases with newer data.

New Hardware and Software

In 2003, the SAC switched from the Windows NT operating system to Windows XP. Multiple copies of the new GIS software, ArcGIS, were also installed. This software was installed as floating licenses, meaning the number of concurrent users is limited, but the software is available on any computer attached to the network. SAC staff supported 26 computers (17 desktops, 6 laptops, and 3 servers) in FY03. One of the laptops and seven of the desktops are outdated and need to be replaced. The three servers hold 219 gigabytes—enough space to house the existing GIS layers and images collected to date. On average, 30 gigabytes of new data are added to the servers each year. A total of 20 GPS units were maintained; 4 Trimble CE units, 3 Trimble ProXL units, 4 Trimble ProXR units, 1 Trimble ProXRS unit, 1 Trimble GeoExplorer II unit, 3 Trimble GeoExplorer III units, and 5 Garmin GPS handheld units. There were also three real-time beacon receivers for use with the Garmin units or the Trimble CE devices. Along with these units, the SAC had four copies of ArcPad (used with the 4 Trimble CE devices), and seven copies of Pathfinder Office.

Outreach

SAC staff continued to make GIS technology directly available to park employees by providing equipment, data, and training. The GIS Lab is available to all employees, and spatial data is accessible over the park network. SAC staff supported GIS software on many computers outside the lab and provided data on CDs to those who are not networked. SAC staff also provided GPS training that

included collecting field data with GPS units, differentially correcting the GPS data, and converting this corrected data into usable GIS layers.

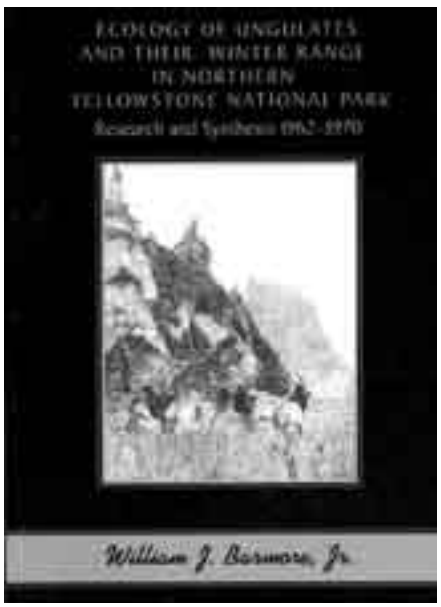
Resource Information and Publications

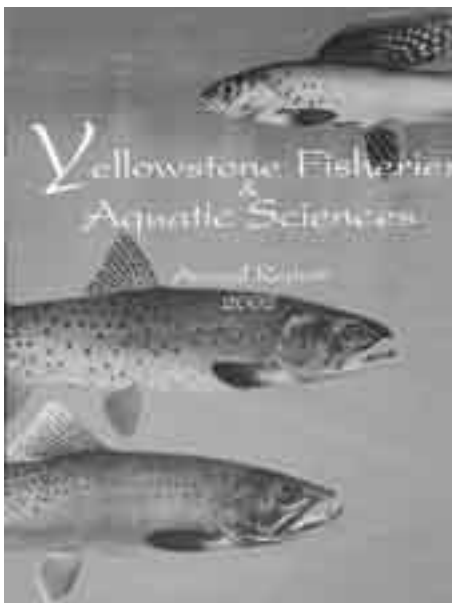
The Resource Information and Publications Team (RIPT) had one staff change in FY03. Virginia Warner joined the staff in April as an editorial assistant, ably taking on the majority of planning responsibilities for the Seventh Biennial Conference on the Greater Yellowstone Ecosystem, lending her talents as an editor, and initiating an interdivisional photo archive database project.

Publications

In 2003, the quarterly journal *Yellowstone Science* entered its eleventh year with a variety of articles highlighting many aspects of Yellowstone's natural and cultural resources. Four issues were published and distributed to a subscription readership of nearly 2,500 individuals and institutions. Two of the four issues were produced in full-color, and all featured an expanded page length from the typical 28 pages to editions that ranged from 32 pages to a 44-page issue in the spring. Among the highlights this year was a commemorative issue in summer 2003 dedicated to the centennial of the Roosevelt Arch, and a well-received spring issue featuring an interview with USGS geologist Lisa Morgan and an accompanying article about her and others' work mapping the floor of Yellowstone Lake. Other feature stories this year included a two-part series by Thomas Brock on the work of the Yellowstone Field Research Expeditions in the 1960s, the environmental legacy of the Muries on the occasion of Mardy Murie's 100th birthday, the search for life by microbiologists in Well Y-7 at Biscuit Basin, Apollinaris Spring through the years, and a look at present-day Gardiner, Montana. "Nature Notes" published in 2003 included a study on wildlife–human conflicts in Yellowstone, bear-on-bear predation in Hayden Valley, and the actions of cutthroat trout preying on flies at Fishing Bridge.

Other publications included six issues of the *Buffalo Chip* newsletter, the *2001 YCR Annual Report* and *2002 YCR Annual Report*, the *2002 Wolf Project Annual Report,* the *2002 Yellowstone Bird Report,* the *2001 Investigators' Annual Report,* and the *2002 Yellowstone Fisheries and Aquatic Sciences Annual Report*. FY03 also marked the long-awaited publication and release of *The Ecology of Ungulates and their Winter Range in Northern Yellowstone National Park, Research and Synthesis, 1962–70,* by William J. Barmore, Jr. RIPT staff also worked collaboratively with the Superintendent's Office and other divisions to oversee the re-writing, editing, layout, and publication (printed and CD versions) of the *Yellowstone National Park Business Plan* and an accompanying business plan brochure, and worked in cooperation with The George Wright Society to co-edit and publish the proceedings of the 6th Biennial Scientific Conference on the Greater Yellowstone Ecosystem, *Yellowstone Lake: Hotbed of Chaos or Reservoir of Resilience?*.





The Barmore book, fish report, and business plan were three of the year's major publications.

Seventh Biennial Scientific Conference

Principal planning, organization, and coordina-

tion was completed for the 7th Biennial Scientific Conference on the Greater Yellowstone, *Beyond the Arch: Community and Conservation in Greater Yellowstone and East Africa,* to take place from October 6–8, 2003 (FY04). Publications and graphic elements produced in support of the conference included a call for papers, preliminary agenda, registration brochure, agenda and abstracts booklet, and posters. Staff also developed a conference website in cooperation with the park's webmaster.

Presentations, Seminars, and Outreach

Resource information staff responded to requests for information on a variety of park topics, made resource-related presentations to a variety of internal and external audiences, provided parkwide seasonal orientation training on resource issues, and coordinated talks by YCR staff with subject matter expertise.

Throughout 2003, staff provided consultations and support to Yellowstone Park Foundation staff in producing update reports on the *Eyes on Yellowstone* project, sponsored by Canon, U.S.A.; provided ongoing support to the *Benefits-Sharing EIS* in the form of reviewing and editing chapters, initiating layout, and producing graphic elements in support of the final product; provided support through a CESU task agreement to authors at Montana State University's Thermal Biology Institute in the development and organization of a book proposal and outline for a forthcoming full color book on Yellowstone microbes, and reviewed and edited the draft manuscript, coordinated map production with the SAC, and provided counsel in review of book proposals and selection of a publisher; provided ongoing support to the Superintendent's Office in the preparation of speeches and remarks for the superintendent and visiting dignitaries at various public functions throughout the year; coordinated the submission of four articles from Yellowstone for the *2002 Natural Resource Year in Review;* prepared Yellowstone's submission to the national NPS website, "Park of the Week" page; and provided technical support to YCR and other park staff by scanning images, producing graphics, assisting with software issues, and helping with audio-visual needs, including PowerPoint presentations.

Research Permitting and Support

In FY03, Yellowstone's Research Permit Office (RPO) authorized 221 research permits to scientists from across the globe; investigators came from roughly 33 states and 7 foreign countries. Of the 221 permits issued, a majority were renewals of previously ongoing studies, though 40 new requests were received and approved by Yellowstone's Research Review Team. Forty-five investigators reported the conclusion of their studies and did not renew their permits.

The Research Review Team, composed of representatives from the Office of Planning and Compliance and the divisions of Maintenance, Resource Management and Visitor Protection, Interpretation, and the Yellowstone Center for Resources), was formed in 1996. The group supports Yellowstone's scientific research program by carefully screening research projects for compliance with NPS regulations and policies, as well as potential impacts to park resources, operations, and visitor experiences. The Research Permit Office also works closely with other YCR staff on research projects that require additional review or guidance.

A wide variety of new projects were initiated in FY03, including several new microbiology and geology studies. The continued interest in the study of microbes was largely due to the unique geothermal environments found in Yellowstone. The increase in geology projects was directly attributable to the formation of the Yellowstone Volcano Observatory.

This virtual observatory is the collaborative effort of Yellowstone, the USGS, and the University of Utah. Although Yellowstone is well known for its wildlife and geothermal systems, a wealth of research related to other topics occurs here. A breakdown by topic is as follows:

Topic	*Number of Permits*
Air, Soil, and Geology	34
Microbiology	44
Lakes, Stream, and Groundwater	12
Vegetation	26
Wildland Fire	6
Bears	4
Birds	5
Bison	5
Elk and Other Ungulates	7
Fish and Aquatic Life	15
Wolves	4
Other Wildlife Species	18
Archeology	5
Paleontology	6
Ethnographic Resources	1
Geographic Information Systems	5
Education and Interpretation	18
Resource Management Planning	6

The Research Permit Office staff continued to provide general park information and logistical support (such as housing, specimen curation, training, and uniformed escorts) to researchers throughout the year. RPO staff also worked diligently to improve communications between researchers and Yellowstone staff by disseminating annual research reports, publications, and theses, as well as organizing research seminars. In August 2003, research permitting and other YCR staff provided assistance and advice to Dr. Ugyen Tshewang of the Kingdom of Bhutan about how to establish a research permitting process for the Bhutan government's National Biodiversity Centre.

In FY03, the National Park Service and Yellowstone National Park were in the fourth year of using a new internet-based program to administer independent research in the national parks. This remarkable new program, called the Research Permit and Reporting System, allows researchers to request permission to conduct research from any national park, nationwide, over the internet. It also acts as a national database, archiving research information and results. Finally, it provides the public with centrally-located access to the results of research projects conducted on NPS lands nationwide.

Montana State University researchers collect small samples of microbes in one of Yellowstone's many geothermal areas.

NPS Servicewide Benefits-Sharing Environmental Impact Statement

The first-ever servicewide EIS will evaluate how best to manage benefits-sharing arrangements with the small number of park-permitted researchers who are commonly characterized as bioprospectors. Bioprospecting is the search for valuable substances in nature—usually bioactive molecules and genetic components—and is an offshoot of permitted research and specimen collection in the national parks. Currently, the NPS facilitates research in parks, but no direct benefits are returned to the parks if an approved research project results in a financially valuable discovery. Existing laws allow for agreements that return benefits to parks if research leads to commercial success. The National Parks Omnibus Management Act of 1998 (Public Law 105-391) specifically authorizes the NPS to enter into "negotiations with the research community and private industry for equitable, efficient benefits-sharing arrangements."

In 1998, a legal challenge to a benefits-

sharing agreement, a CRADA (cooperative research and development agreement) negotiated between Yellowstone National Park and Diversa Corporation resulted in the judge dismissing the case with prejudice. CRADAs were ruled to be consistent with the National Park Service Organic Act and Yellowstone National Park's enabling legislation. As a result of a prior order from the same court, the NPS was directed to conduct an analysis under NEPA (the National Environmental Policy Act of 1969), which the EIS effort addresses. The EIS process provides for public dialogue on issues surrounding benefits-sharing as well as a means to evaluate potential environmental effects related to a set of alternative approaches to managing benefits-sharing when research involving biological specimens collected from NPS units yields commercially valuable results.

The EIS, which applies to all units of the National Park System, evaluates and compares potential means to implement benefits-sharing within the NPS and their resultant effects, including a "no action" alternative that would preclude parks from engaging in benefits-sharing. None of the actions proposed by the National Park Service would weaken long-standing research and collection approval policies intended to protect park resources, nor would additional collections be authorized under benefits-sharing agreements. Prohibitions on the sale and unauthorized transfer of specimens collected in NPS units would not be altered by any of the actions proposed.

Staffing and EIS Teams

The Benefits-Sharing NEPA Team consists of YCR staff Sue Mills (Project Manager), John Varley, and Ann Deutch; and Preston Scott, Thom Minner, and Mansir Petrie of the World Foundation for Environment and Development, contracted to draft and review portions of the EIS and to provide legal and technical expertise in the fields of bioprospecting and benefits-sharing. Additional YCR staff members provided key assistance to the EIS effort, including Sara Housley, who re-organized and maintains the EIS's administrative record. Alice Wondrak Biel and Sarah Stevenson provide editorial and graphical layout expertise, respectively.

In support of the EIS effort, the NEPA team works with the NPS's Washington-level Bioprospecting Management Committee and the EIS's Interdisciplinary Team (IDT), which provide input and feedback on the development of the draft EIS. The IDT includes members from representative parks and central offices from all regions of the NPS. The Bioprospecting Management Committee is co-chaired by John Varley and Mike Soukup, NPS Associate Director for Natural Resources in the Washington Office.

Funding, Personnel, and Administrative Support

Base Operating Budget

A base operating budget of $3,418,700 for the YCR was approved by Superintendent Suzanne Lewis and Deputy Superintendent Frank Walker April 3, 2003. This represented a decrease of $16,100 from FY02 funding levels, and was 62% of the total YCR budget for FY03.

Additional Funding

Recreation Fee Demonstration funds. New funding of $103,000 was made available to continue a rare books restoration project and northern range riparian studies. No funds were granted for new resource management project starts in FY03 under this program. The overall amount allocated to YCR since the inception of the program is approximately $1,400,000 for 18 individual projects.

Fishing fee program. The YCR received authorization to use $250,000 from fishing permit fee revenue to partially cover the estimated $800,000 total cost of the aquatic resources program in FY03.

Federal Lands Highway Program. Federal Highways funded $431,000 for natural resource inventories, archeological surveys, and resource compliance along the road corridors in the park scheduled for major repair or reconstruction in the near future.

Special Emphasis Program Allocation System. In FY03, the Branch of Natural Resources received $101,000 from this funding source to begin an elk calf mortality study and a streamflow restoration project on Reese Creek, and to continue a baseline inventory of aquatic thermophiles.

The Branch of Cultural Resources successfully competed for a total of $326,300 in special emphasis program funding. These funds were used for

improving storage conditions in the collections facility, a joint ethnographic resource inventory with Grand Teton National Park, two cataloging projects, and Phase II of the Black Canyon archeological site salvage project.

Other NPS funds. Two of the most significant projects undertaken by YCR in FY03 on non-base funds were the lake trout control program and the initiation of wildlife, air quality, and water quality monitoring programs relative to the park's Winter Use EIS. These important projects will continue in future fiscal years as base-funded programs. The Save America's Treasures program provided funding to catalog and preserve Yellowstone's vast collection of historic architectural drawings. A portion of Line Item Construction funds the park received to accomplish three large projects was dedicated to the natural and cultural resources planning and compliance efforts necessary to proceed with structural improvements. YCR also administered funds and provided support for two NPS-sponsored projects in FY03 that are not included as part of YCR's funding history; the servicewide Benefits-Sharing EIS, and the regional Greater Yellowstone Network (GRYN) Inventory and Monitoring project.

Other federal funds. YNP joined forces with other regional land management agencies on several ecosystemwide projects in FY03. The Greater Yellowstone Coordinating Committee (GYCC) elected to fund two aquatic resources projects, one focusing on the restoration of westslope cutthroat trout to the ecosystem, and another to collect information on native cutthroat trout in the Upper Yellowstone River region. The Gallatin National Forest provided funds to Yellowstone's Spatial Analysis Center to begin a Greater Yellowstone Area (GYA) fuel model mapping project for wildland fire applications. The creation of an oral history CD about the 1877 flight of the Nez Perce tribe through Yellowstone was made possible through an interagency agreement with the Clearwater National Forest in the state of Idaho.

Private funds. A total of $224,300 was donated to the park by private organizations or individuals in support of whirling disease surveys, a lynx population survey, wolf recovery program operations, an experimental electronic data collection project named Eyes on Hayden, and the trial year of the Tauck World Discovery volunteer program.

Personnel

There were 241 personnel actions processed in FY03. Of special note were the following:

- Beginning in early November 2002, Cultural Resources Support Assistant Maurine Hinckley-Cole took a six-month leave of absence due to family illness. The YCR administrative staff welcomed new NPS employee Tasha Felton as temporary backfill for Maurine. Thanks to her unique combination of academic qualifications and Peace Corps service, Tasha was eligible to be converted to a permanent position as a Cultural Resources Technician when Maurine returned in May 2003.
- In January 2003, Museum Curator Susan Kraft resigned from the National Park Service to pursue other interests. Museum Aide Beth Raz also resigned that same month in order to devote herself to full-time studies at Montana State University.
- Colleen Curry, formerly the curator at Arlington House, the Robert E. Lee Memorial in Virginia, was selected as Curator, and joined the staff in June 2003.
- Following an 18-month detail to Yellowstone, Dr. Henry Heasler, from the University of Wyoming, was selected for the permanent Geologist position and began his first official appointment with the National Park Service in June 2003.
- Eric Reinertson and John Treanor, permanent Biological Science Technicians with the Bison Ecology and Management Office, left their positions in April and August 2003, respectively. Eric accepted a promotion to Resource Management Coordinator at Grant Village in Yellowstone, and John was accepted into a graduate program at the University of Kentucky in Lexington.
- Secretary Beth Taylor accepted a promotion to Park Ranger with the Division of Interpretation at Old Faithful, and left the YCR in August 2003.
- The Aquatic Resources and Fisheries program successfully recruited Small Craft Operator Don Wethington into a permanent, subject-to-furlough position this year, and also welcomed

Biological Science Technician Phillip Doepke to the lake trout control program in September 2003.

- Upon the completion of her Master's degree from the University of Montana, SCEP employee Elaine Hale accepted a full-time, permanent Archeologist position with the Branch of Cultural Resources.

Contracting

Thirty-two contracting actions were processed in FY03, totaling obligations of $763,800, primarily for interagency and university assistance agreements. Significant contracting actions involved research in support of winter use studies, administration of the Montana Water Compact, archeological surveys and evaluations, aquatic resources studies, geology program support and monitoring, and an historic document preservation project.

Procurement Actions

There were 950 procurement actions processed in FY03, totaling approximately $1,366,200.

Clerical Support

There were 1,064 pieces of correspondence and 592 travel authorizations processed in FY03.

Table 1. Funding history, Center for Resources, Yellowstone National Park (new allocations only), FY93–03.

		NPS FUNDS									
YCR BASE INCREASE	FY	PARK BASE	NAT RES PROJECT FUNDS	CULT RES PROJECT FUNDS	FISH FEE	FLHP	FEE DEMO	OTHER NPS	OTHER FEDERAL	PRIVATE	TOTAL
	1993	1,004,600	16,000	-	-	-	-	785,000	188,000	20,000	2,013,600
245,400	1994	1,250,000	260,000	33,200	65,000	43,300	-	320,600	79,600	10,000	2,061,700
250,000	1995	1,500,000	420,000	45,000	65,000	303,600	-	59,800	20,000	5,300	2,418,700
44,100	1996	1,544,100	404,000	201,000	274,500	626,700	-	157,800	65,000	31,500	3,304,700
130,000	1997	1,674,100	204,000	228,400	213,400	433,700	340,000	42,700	398,300	48,000	3,582,600
571,500	1998	2,245,600	130,500	242,100	284,800	330,800	31,000	24,000	65,300	37,700	3,391,800
286,300	1999	2,531,900	-	221,900	285,000	396,500	298,000	152,900	105,200	56,700	4,048,100
36,700	2000	2,568,600	237,500	101,000	280,000	214,900	631,000	1,418,000	41,300	52,700	5,545,000
93,300	2001	2,661,900	297,000	216,700	285,100	409,000	-	-	15,000	85,500	3,970,200
772,900	2002	3,434,800	293,000	198,700	261,900	293,200	6,000	-	11,700	126,400	4,625,700
(16,100)	2003	3,418,700	101,000	326,300	250,000	431,000	103,000	454,400	24,000	224,300	5,332,700

Table 2. YCR distribution of FY03 funds (includes carryover).

	NPS FUNDS										
	PARK BASE	NAT RES PROJECT FUNDS	CULT RES PROJECT FUNDS	FISH FEE	FLHP	FEE DEMO	OTHER NPS	OTHER FEDERAL	PRIVATE	TOTAL	% OF TOTAL FUNDING
Support	918,100	-	-	-	31,200	2,100	-	-	900	952,300	17.4
Natural resources	2,027,600	101,000	-	250,000	202,400	198,100	341,000	18,000	218,300	3,356,800	61.3
Cultural resources	473,000	-	326,300	-	197,400	45,100	113,000	6,000	5,100	1,165,900	21.3
Total	3,418,700	101,000	326,300	250,000	431,000	245,300	454,400	24,000	224,300	5,475,000	100

Appendix I.
Personnel Roster for Fiscal Year 2003

Professional Support Branch

	Management and Administration		FTE	Borrowed FTE
1	Wayne Brewster	Deputy Director	1.00	
2	Elizabeth Cleveland	Administrative Support Assistant	0.85	
3	Ann Deutch	Administrative Support Assistant	0.61	
4	Christie Hendrix	Environmental Protection Specialist	1.00	
5	Sara Housley	Center Clerk	0.08	
6	Judy Lanning	Maintenance Worker		0.02
7	Melissa McAdam	Supervisory Budget Analyst	1.00	
8	Sue Mills	Environmental Protection Specialist	1.00	
9	Joy Perius	Budget Analyst	1.00	
10	Beth Taylor	Secretary	0.93	
11	John Varley	Director	1.00	
12	Colleen Watson	Administrative Support Assistant	1.00	
	subtotal Management and Administration		***9.47***	***0.02***
	Resource Information and Publications Team			
13	Roger Anderson	Resource Management Specialist	1.00	
14	Tami Blackford	Technical Writer-Editor	0.50	
15	Renee Evanoff	Visual Information Specialist	0.04	
16	Paul Schullery	Resource Naturalist	0.47	
17	Sarah Stevenson	Technical Writer-Editor	0.24	
18	Virginia Warner	Editorial Assistant	0.56	
19	Alice Wondrak Biel	Technical Writer-Editor	1.00	
	subtotal Resource Information and Publications Team		***3.81***	
	Spatial Analysis Center			
20	Erin Campbell	Cartographic Technician	0.29	
21	Ben Dorsey	Cartographic Technician	0.60	
22	Carrie Guiles	Cartographic Technician	0.40	
23	Adam Kiel	Cartographic Technician	0.26	
24	Ryan Liddell	Cartographic Technician	0.25	
25	Kendra Maas	Cartographic Technician	0.26	
26	Steve Miller	Cartographic Technician	0.56	
27	James Napoli	Cartographic Technician	0.89	
28	Ann Rodman	Supervisory GIS Specialist	1.00	
29	Shannon Savage	GIS Specialist	0.60	
30	Michael Walkinshaw	Cartographic Technician	0.29	
	subtotal Spatial Analysis Center		***5.40***	
	Professional Support Branch FTE		**18.68**	**0.02**

Natural Resources Branch

	Natural Resources Administration		FTE	Borrowed FTE
1	Rebecca Anthony	Administrative Support Assistant	1.00	
2	Tom Olliff	Chief, Branch of Natural Resources	1.00	
	subtotal Natural Resources Administration		***2.00***	
	Wildlife Resources Team			
3	Nathan Berg	Biological Science Technician	0.48	
4	Mark Biel	Wildlife Biologist	1.00	
5	Doug Blanton	Biological Science Technician	0.41	
6	Kevin Castle	Veterinary Student		0.01
7	Susan Chin	Biological Science Technician	1.00	
8	Trevor Clark	Biological Science Technician	0.29	
9	Troy Davis	Biological Science Techinician	0.85	
10	Ben Dorsey	Cartographic Technician	0.34	
11	Chris Geremia	Biological Science Technician	0.80	
12	Rachael Gray	Biological Science Technician	1.00	
13	Gina Griffeth	Biological Science Technician	0.23	
14	Debra Guernsey	Biological Science Technician	0.98	
15	Kerry Gunther	Wildlife Biologist	1.00	
16	Justin Hadwen	Biological Science Technician	0.46	
17	Scott Jawors	Biological Science Technician	0.35	
18	M.T. Jones	Biological Science Technician	0.28	
19	Ryman LeBeau	Biological Science Technician	0.25	
20	Terry McEneaney	Wildlife Biologist	1.00	
21	Rick McIntyre	Biological Science Technician	0.50	
22	Kerry Murphy	Wildlife Biologist	1.00	
23	Melissa Peer	Biological Science Technician	0.06	
24	Glenn Plumb	Supervisory Wildlife Biologist	0.98	
25	Derek Poinsette	Biological Science Technician	0.57	
26	Tiffany Potter	Biological Science Technician	0.99	
27	Eric Reintertson	Biological Science Technician	0.54	
28	Lori Roberts	Biological Science Technician	0.45	
29	Monty Simenson	Horse Handler		0.46
30	Doug Smith	Wildlife Biologist	1.00	
31	Dan Stahler	Biological Science Technician	0.98	
32	Jeremiah Smith	Biological Science Technician	0.37	
33	Janice Stroud	Biological Science Technician	0.35	
34	Aimee Tallian	Biological Science Technician		0.11
35	Linda Thurston	Biological Science Technician		0.23
36	John Treanor	Biological Science Technician	0.85	
37	Richard Wallen	Wildlife Biologist	1.00	
38	Brian Wheat	Biological Science Technician	0.10	
39	P.J. White	Wildlife Biologist	1.00	
40	Travis Wyman	Biological Science Technician	1.00	
	subtotal WRT		***22.46***	***0.81***

Aquatic Resources and Fisheries		FTE	Borrowed FTE
41 Jeff Arnold	Ecologist	1.00	
42 Pat Bigelow	Fishery Biologist	1.00	
43 Tim Bywater	Administrative Support Assistant	0.28	
44 Trevor Clark	Biological Science Technician	0.46	
45 Matthew Delheimer	Biological Science Technician	0.09	
46 Chris Dixon	Biological Science Technician	0.41	
47 Philip Doepke	Biological Science Technician	0.08	
48 Brian Ertel	Biological Science Technician	1.00	
49 Joseph Facendola	Biological Science Technician	0.40	
50 Renee Farias	Administrative Support Assistant	0.11	
51 Scott Favrot	Biological Science Technician	0.47	
52 Ryan Harnish	Biological Science Technician	0.05	
53 Shane Keep	Biological Science Technician	0.42	
54 Todd Koel	Supervisory Fisheries Biologist	1.00	
55 Nicole Legere	Biological Science Technician	0.26	
56 Dan Mahony	Fishery Biologist	1.00	
57 Anna Maki	Biological Science Technician	0.09	
58 Misayo Matsuda	Biological Science Technician	0.07	
59 Tyler Mintkeski	Biological Science Technician	0.35	
60 Theresa Morgan	Biological Science Technician	0.09	
61 Brad Olszewski	Biological Science Technician	0.30	
62 Barbara Rowdon	Biological Science Technician	1.00	
63 Michael Ruhl	Biological Science Technician	0.33	
64 Stacy Sigler	Biological Science Technician	0.40	
65 Kelly Slattery	Biological Science Technician	0.25	
66 Amber Steed	Biological Science Technician	0.39	
67 Gary Vonderohe	Biological Science Technician	0.42	
68 Don Wethington	Maintenance Worker	0.54	
69 Davina White	Biological Science Technician	0.46	
subtotal Aquatic Resources		***12.72***	

Vegetation Management			
70 Heidi Anderson	Botanist	0.91	
71 William Edwards	Biological Science Technician	0.31	
72 Mary Hektner	Resource Management Specialist	0.99	
73 John Klaptosky	Biological Science Technician	0.34	
74 Vicki Pecha	Biological Science Technician	0.54	
75 Roy Renkin	Vegetation Management Specialist	0.91	
76 Jennifer Whipple	Botanist	0.83	
subtotal Vegetation Management		***4.83***	

Geology and Physical Sciences			
77 Carrie Guiles	Physical Science Technician	0.34	
78 Henry Heasler	Supervisory Geologist	0.33	
79 Cheryl Jaworowski	Geologist	0.23	
80 Steve Miller	Physical Science Technician	0.44	
81 Tim Thompson	Physical Science Technician	0.09	
subtotal Geology		***1.43***	

	Greater Yellowstone Network Inventory & Monitoring Program		FTE	Borrowed FTE
82	Chad Jacobson	Cartographic Technician	0.17	
	subtotal I&M		***0.17***	
	NATURAL RESOURCES BRANCH FTE		**43.61**	**0.81**

CULTURAL RESOURCES BRANCH

1	David Amott	Museum Technician	0.23	
2	Sean Cahill	Museum Technician	1.00	
3	Bridgette Case	Museum Technician	0.24	
4	Sue Consolo Murphy	Chief, Branch of Cultural Resources	1.00	
5	Colleen Curry	Curator	0.34	
6	Herbert Dawson	Architect	1.00	
7	Gabrielle Elliott	Cartographic Technician		0.06
8	Tasha Felton	Cultural Resources Technician	0.85	
9	Jessica Gerdes	Museum Technician	0.02	
10	Elaine Hale	Cultural Resources Technician	1.00	
11	Maurine Hinckley-Cole	Administrative Support Assistant	0.42	
12	Harold Housley	Archives Specialist	1.00	
13	Sarah Housley	Center Clerk	0.05	
14	Ann Johnson	Archeologist	1.00	
15	Linda Juneau	Cultural Resources Technician	0.01	
16	Susan Kraft	Supervisory Museum Curator	0.28	
17	Alice Newton	Registrar		0.05
18	Beth Raz	Museum Aide	0.28	
19	Charissa Reid	Cultural Anthropologist	0.20	
20	Rosemary Sucec	Cultural Anthropologist	1.00	
21	Steve Tustanowski-Marsh	Museum Technician	1.00	
22	Lee Whittlesey	Historian	1.00	
	CULTURAL RESOURCES BRANCH FTE		**11.92**	**0.11**

TOTAL YCR FY03 FTE 74.21 0.94

Appendix II. Publications, Reports, and Papers

Professional Publications

Ballard, W.B., L.N. Carbyn, and D.W. Smith. 2003. Wolf interactions with non-prey. Pages 259–271 in *Wolves: behavior, ecology, and conservation,* L.D. Mech and L. Boitani, eds. Chicago: University of Chicago Press.

Barmore, W.J. 2003. *The ecology of ungulates and their winter range in northern Yellowstone National Park, research and synthesis, 1962–70*. Yellowstone Center for Resources, Yellowstone National Park.

Carroll, C., M.K. Phillips, N.H. Schumaker, and D.W. Smith. 2003. Impacts of landscape change on wolf restoration success: planning a reintroduction program based on static and dynamic spatial models. *Conservation Biology* 17(2): 536–548.

Consolo Murphy, S., and D.W. Smith. 2003. Documenting trends in Yellowstone's beaver population: a comparison of aerial and ground surveys in the Yellowstone Lake basin, in *Yellowstone Lake: hotbed of chaos or reservoir of resilience? Proceedings of the 6th Biennial Scientific Conference on the Greater Yellowstone Ecosystem. October 8–10, 2001, Mammoth Hot Springs Hotel, Yellowstone National Park,* R.J. Anderson and D. Harmon, eds. Yellowstone National Park, Wyo., and Hancock, Mich.: Yellowstone Center for Resources and The George Wright Society.

Eberhardt, L.L., R.A. Garrott, D.W. Smith, P.J. White, and R.O. Peterson. 2003. Assessing the impact of wolves on ungulate prey. *Ecological Applications* 13(3): 776–783.

Fahnestock, J.T., D.L. Larson, G.E. Plumb, and J.K. Detling. 2003. Effects of ungulates and prairie dogs on seed banks and vegetation in a North American mixed-grass prairie. *Plant Ecology* 167: 255–268.

Felicetti, L.A., C.C. Schwartz, R.O. Rye, M.A. Haroldson, K.A. Gunther, D.L. Phillips, and C.T. Robbins. 2003. Use of sulfur and nitrogen stable isotopes to determine the importance of whitebark pine nuts to Yellowstone grizzly bears. *Canadian Journal of Zoology* 81:763–770.

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Garrott, R.A., L.L. Eberhardt, P.J. White, and J. Rotella. 2003. Climate-induced variation in vital rates of an unharvested large-herbivore population. *Canadian Journal of Zoology* 81: 33–45.

Haight, R.G., B. Cypher, P.A. Kelly, S. Phillips, H.P. Possingham, K. Ralls, A.M. Starfield, P.J. White, and D. Williams. 2002. Optimizing habitat protection using demographic models of population viability. *Conservation Biology* 16: 1386–1397.

Hale, E.S. 2003. A Culture History of the Yellowstone River and Yellowstone Lake, Yellowstone National Park, Wyoming and Montana. Unpublished Master's thesis, University of Montana, Missoula.

Johnson, A.M. 2003. Archeology around Yellowstone Lake, in *Yellowstone Lake: hotbed of chaos or reservoir of resilience? Proceedings of the 6th Biennial Scientific Conference on the Greater Yellowstone Ecosystem. October 8–10, 2001, Mammoth Hot Springs Hotel, Yellowstone National Park,* R.J. Anderson and D. Harmon, eds. Yellowstone National Park, Wyo., and Hancock, Mich.: Yellowstone Center for Resources and The George Wright Society.

Larkin, J.L., J. Treanor, J. Cox, H. Loring, D.S. Maher, and G. Plumb. 2003. A comprehensive rapid-assessment approach for research agenda development: elk *(Cervus elaphus)* at Yellowstone National Park. Unpublished Technical Report, Yellowstone National Park, Mammoth Hot Springs, Wyo. 177pp.

McEneaney, T. 2003. Piscivorous birds of Yellowstone Lake: their history, ecology, and status, in *Yellowstone Lake: hotbed of chaos or reservoir of resilience? Proceedings of the 6th Biennial Scientific Conference on the Greater Yellowstone Ecosystem. October 8–10, 2001, Mammoth Hot Springs Hotel, Yellowstone National Park,* R.J. Anderson and D. Harmon, eds. Yellowstone National Park, Wyo., and Hancock, Mich.: Yellowstone Center for Resources and The

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Ruth, T.K., D.W. Smith, M.A. Haroldson, P.C. Buotte, C. Schwartz, H. Quigley, S. Cherry, K.M. Murphy, D.B. Tyers, and K. Frey. 2003. Large-carnivore response to recreational big-game hunting along the Yellowstone National Park and Absaroka-Beartooth Wilderness boundary. *Wildlife Society Bulletin* 31: 1150–1161.

Samson, F.B., F.L. Knopf, C.W. McCarthy, B.R. Noon, W.R. Ostlie, S.M. Rinehart, S. Larson, G.E. Plumb, G.L. Schenbeck, D.N. Svingen, and T.W. Byer. 2003. Planning for population viability on northern Great Plains national grasslands. *Wildlife Bulletin* 31: 986–999.

Sargeant, G.A., P.J. White, M.A. Sovada, and B.L. Cypher. 2003. Scent-station survey techniques for swift and kit foxes. Pages 99–105 in *The swift fox: ecology and conservation of swift foxes in a changing world*, M.A. Sovada and L. Carbyn, eds. Canadian Plains Research Center, Saskatchewan.

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Schullery, P. 2003. The Legacy of the National Park Service. Short article in *The Roosevelt Arch*, National Park Service newspaper insert, August 4, Yellowstone National Park.

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Smith, D.W., D.R. Stahler, and D.S. Guernsey. 2003. Yellowstone Wolf Project: Annual Report 2002. National Park Service, Yellowstone Center for Resources, Yellowstone National Park, Wyoming, YCR-NR-2003, 14pp.

Stahler, D.R., D.W. Smith, R. McIntyre, E. West, B. Phillips, B. Chan, M. Ross, J. Knuth Folts, D. Chalfant, and B. Suderman. 2003. Managing wolves and humans in Lamar Valley: A final report on the Druid road project 2003. YNP Report. 9pp.

Whipple, J.J. 2003. Review of *A flora of Glacier National Park*, by Peter Lesica. *Madroño* 50 (2): 127–128.

Whipple, J.J. 2003. Yellowstone sand verbena (*Abronia ammophila*): a Yellowstone Lake endemic, in *Yellowstone Lake: hotbed of chaos or reservoir of resilience? Proceedings of the 6th Biennial Scientific Conference on the Greater Yellowstone Ecosystem. October 8–10, 2001, Mammoth Hot Springs Hotel, Yellowstone National Park*, R.J. Anderson and D. Harmon, eds. Yellowstone National Park, Wyo., and Hancock, Mich.: Yellowstone Center for Resources and The George Wright Society.

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Whittlesey, L. 2003. Native Americans, the earliest interpreters: what is known about their legends and stories of Yellowstone National Park and the complexities of interpreting them, *George Wright Forum* 19(3): 40–51, and in *Yellowstone Lake: hotbed of chaos or reservoir of resilience? Proceedings of the 6th Biennial Scientific*

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Wilmers, C.C., D.R. Stahler, R.L. Crabtree, D.W. Smith, and W.M. Getz. 2003. Resource dispersion and consumer dominance: scavenging at wolf- and hunter-killed carcasses in Greater Yellowstone, USA. *Ecology Letters* 6: 996–1003.

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Culpin, M.S., E. Hale, and N. McClure. 2003. National Register Nomination for the Grand Loop Road Historic District, Yellowstone National Park, Wyoming. National Register of Historic Places, NPS, Washington, D.C.

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Gunther, K.A. 2003. Yellowstone National Park bear-related injuries/fatalities. Information Paper No. BMO-1. U.S. Department of the Interior, National Park Service, Yellowstone National Park. 2pp.

Gunther, K.A. 2003. Food habits of grizzly bears and black bears in the Yellowstone ecosystem. Information Paper No. BMO-3. U.S. Department of the Interior, National Park Service, Yellowstone National Park. 3pp.

Gunther, K.A. 2003. Where are all the bears? Information Paper No. BMO-4. U.S. Department of the Interior, National Park Service, Yellowstone National Park. 2pp.

Gunther, K.A. 2003. Bear management area program, Yellowstone National Park. Information Paper No. BMO-5. U.S. Department of the Interior, National Park Service, Yellowstone National Park. 4pp.

Gunther, K.A. 2003. Recovery parameters for grizzly bears in the Yellowstone ecosystem. Information Paper No. BMO-6. U.S. Department of the Interior, National Park Service, Yellowstone National Park. 4 pp.

Gunther, K.A. 2003. Bears and menstruating women. Information Paper No. BMO-7. U.S. Department of the Interior, National Park Service, Yellowstone National Park. 2pp.

Appendix III. Partnerships

Standing Partnerships

YCR staff contribute to international, national, and regional resource stewardship efforts by participating in the following ongoing partnerships:

Cultural Resources

Federal Highways Road Team

Mission: Context-sensitive design, improvement, and reconstruction of YNP's principal historic roads. The road team is intimately involved in all phases of NEPA, historic preservation, wetlands, and Endangered Species Act compliance.

Commitment: Weekly conference calls, two four-day sessions walking the road corridor along each segment of road to be reconstructed, winter meetings.

Representatives: Mary Hektner and Elaine Hale

2003 Highlights: National and regional design awards for customer satisfaction, and design awards for environmental sensitivity for work on segments of the Grand Loop Road Historic District.

National Park Service Ethnographic Resources Inventory (ERI) National Data Standards and Implementation Committee

Mission: A committee, representative of NPS parks and regions, was formed in 2002 to consider how the ERI system is operating, identify any needed changes, consider interface with other servicewide data systems, and address operational and conceptual needs as they arise. Members include the NPS's Chief Ethnographer; the NPS's Archeology and Ethnography Program Manager; regional representatives from the Alaska, Midwest, Northeast, and Southeast regions; NPS ethnographers from Yellowstone and Olympic national parks, and the contractor who developed the software.

Commitment: Telephone conference calls every quarter and on an as-needed basis. Attendance at the annual meeting of NPS ethnographers.

Representative: Rosemary Sucec

2003 Highlights: The committee tested a new, beta version of the ERI during the last six months of the fiscal year. Problems were identified and submitted to the contractor. It is expected that in 2004, the amended version will be approved for use servicewide. The Ethnography Program initiated a conversation with the park's GIS program to talk about interface between the two systems.

Partnerships with 26 American Indian Tribes

Mission: Yellowstone National Park regularly consults with governmental representatives from 26 park-associated and 54 bison-interested American Indian tribes. These partnerships enable the park to manage its cultural and natural resources in a sensitive, culturally informed manner.

Commitment: Each spring, tribes are invited to come to the park for a full day's meeting to hear about the most pressing management issues in natural and cultural resources. A welcoming potluck is held, and field trips are usually offered. In the fall, park personnel travel to one of the reservations of a park-associated tribe to learn more about them, as well as any needs the tribe has with which YNP managers might be able to help.

Representative: Rosemary Sucec

2003 Highlights: More than 55 individuals representing 21 tribes and one pan-Indian organization attended the June 5 meeting. More than 100 tribal representatives, their families, park staff, and community members attended the potluck. In November, Deputy Superintendent Frank Walker, Rick Wallen, and Rosemary Sucec met with the Shoshone-Bannock Tribes' governing council. The Tribes expressed interest in the park's management of the Bannock Trail; as a result, the park has elevated its attention to documenting the trail and is looking at management options in tandem with the tribes.

The Tauck World Discovery/Tauck Bridges Yellowstone Volunteer Program

Mission: To provide Tauck guests the opportunity to volunteer in Yellowstone National Park, and provide the park with the ability to complete projects relative to its historic structures program that otherwise would not have been done.

Commitment: Approximately one week per month during spring through fall, plus several days each month during winter.

Representative: Herb Dawson

2003 Highlights: 1,600 volunteers gave over 3,000 hours to various projects related to the park's historic structures.

Virginia City National Historic Landmark District Stabilization Partnership

Mission: To administer, with the Montana Heritage Commission (MHC), the expenditures of a $1.7 million grant to the MHC from the National Park Service, and provide technical assistance and liaison with the MHC, the NPS, private consultants, contractors, and the Montana State Historic Preservation Commission.

Commitment: Three days per month.

Representative: Herb Dawson

2003 Highlights: Seismic stabilization of the Kiskadden Barn, structural stabilization of Content's Corner, interior rehabilitation and restoration, and construction of a water system and fire protection system for the district's buildings. Projects were planned for the Gilbert Brewery and associated buildings, and the partners worked with a potential donor on Stonewall Hall, the first meeting place of the Montana Territorial Legislature, which is in dire need of stabilization and almost ready to collapse.

Yellowstone Area Museum Partnership

Mission: To support the preservation and interpretation of the historical, cultural, and natural history of the Greater Yellowstone Area by coordinating efforts, minimizing redundancy, and sharing ideas, expertise, and resources. Members include the Buffalo Bill Historical Center (Cody, Wyo.), the Western Heritage Center and the Yellowstone Art Museum (Billings, Mont.), the Wind River Historical Center (Dubois, Idaho), the Yellowstone Historic Center (West Yellowstone, Mont.), the Livingston Depot Center, International Fly Fishing Center, and the Yellowstone Gateway Museum (Livingston, Mont.), the Museum of the Rockies (Bozeman, Mont.), the National Museum of Wildlife Art (Jackson, Wyo.), the Homesteader's Museum and Park County Museum Board (Powell, Wyo.), and Yellowstone National Park.

Commitment: Semi-annual meetings.

Representative: Colleen Curry

2003 Highlights: Park staff were not able to participate in 2003 due to the closure of the park's collections in preparation for the move to the Yellowstone Heritage and Research Center.

Natural Resources

Air Quality Monitoring

Mission: To monitor air quality (carbon monoxide and particulate matter ($PM^{2.5}$) at the park's West Entrance. The Montana Department of Environmental Quality is the park's partner in this endeavor.

Commitment: A three-year cooperative agreement.

Representative: Mary Hektner

2003 Highlights: Air quality monitoring at the West Entrance over the past several winters has revealed a significant carbon monoxide (CO) problem. Under conditions of poor pollutant dispersion, the CO concentration has approached the National Ambient Air Quality Standard on several occasions, and it does not seem unreasonable to believe that under extremely unfavorable circumstances it could exceed the standard. The NPS and MTDEQ recently completed a supplemental environmental impact statement on winter use management. This plan calls for an adaptive management strategy to determine if goals related to park resources and values are being met, and make adjustments in management if they are not. Monitoring CO and PM is fundamental to adaptive management to ensure that Yellowstone's Class I airshed is not being adversely affected, and to provide park managers with credible information to make future management decisions.

Greater Yellowstone Area Clean Air Partnership

Mission: The partnership serves as an advisory group to the Greater Yellowstone Coordinating Committee and is a forum for information exchange to facilitate air program coordination and the implementation of consistent air quality management strategies. The partnership is made up of Yellowstone and Grand Teton national parks; Gallatin, Custer, Beaverhead, Shoshone, Bridger-Teton, and Targhee national forests; Red Rock Lakes National Wildlife Refuge; the Idaho National Environmental and Energy Laboratory; and the Montana, Idaho, and Wyoming Departments of Environmental Quality.

Commitment: Annual meeting.

Representative: Mary Hektner

2003 Highlights: Information on visibility data, air quality rule making, Yellowstone's "greening" efforts, and snow deposition chemistry studies was shared during the annual meeting.

Greater Yellowstone Bald Eagle Working Group

Mission: Established in 1982, this group monitors bald eagle productivity and other information. Participants include GYA state and federal government agencies and non-governmental organizations.

Commitment: Previously annual meetings, but a meeting has not been held in the last four years. Information is communicated via e-mail.

Representative: Terry McEneaney

2003 Highlights: The bald eagle is ecologically recovered in the greater Yellowstone area. The group is unified in its belief that the bald eagle can be delisted in this area, and the U.S. Fish and Wildlife Service is expected to take such action in the near future.

Greater Yellowstone Interagency Brucellosis Committee (GYIBC)

Mission: The GYIBC was formed through a Memorandum of Agreement between the Secretaries of the Department of Agriculture and Interior and the governors of Montana, Wyoming, and Idaho. The GYIBC has an executive committee and two subcommittees, the technical subcommittee, and the information and education subcommittee. Through its executive committee, the agreed upon scope of work for the GYIBC is to develop options and recommendations for member agencies in charting a management program for brucellosis-affected wildlife populations and their habitat in the GYA; provide coordination of agency responsibilities without usurping agency mandates; encourage cooperation in resolving resource problems and conflicting interests related to brucellosis in wildlife; and provide guidance and oversight to subcommittees. The technical subcommittee, which serves at the direction of the executive committee, will develop a comprehensive, objective, and scientific base of information and recommend strategies based on common understanding of brucellosis and its impacts on the resources of the GYA; and serve as the scientific advisor to the GYIBC. The information and education subcommittee will develop factual information regarding the purpose of the GYIBC for public distribution and will develop a brucellosis information and education strategic plan for the GYIBC.

Commitment: The NPS-IMR Regional Director is represented on the executive committee by the Associate Regional Director for Natural Resources and Science. Yellowstone provides a representative for the technical subcommittee, currently Wayne Brewster. He has served a two-year term as the technical subcommittee's chairman. Technical and executive committee meetings are held three times annually.

Representative: Wayne Brewster

2003 Highlights: Participation in committee meetings as well as completion of technical subcommittee assignments.

Greater Yellowstone Peregrine Falcon Working Group

Mission: To continue to facilitate the recovery of the peregrine falcon in the greater Yellowstone area. The park works closely with two peregrine falcon working groups, Montana and Wyoming, and has been an active participant since peregrines have been found in greater Yellowstone. Yellowstone also works closely with the Peregrine Fund.

Commitment: Wyoming has an informal working group, with coordination done over the telephone. Montana has a more formalized working group with an annual meeting.

Representative: Terry McEneaney

2003 Highlights: The staff ornithologist attended the January 2003 meeting of the Montana working group.

Greater Yellowstone Trumpeter Swan Working Group

Mission: To collect annual population and production data on trumpeter swans in the GYA.

Commitment: Management activities are communicated between agencies at meetings.

Representative: Terry McEneaney

2003 Highlights: The staff ornithologist participated in the fall 2003 meeting held in West Yellowstone, Montana.

Harlequin Duck Working Group

Mission: This group is an international (U.S. and Canada) and interagency (state, federal, and provincial) group designed to share harlequin duck information and data.

Commitment: Yellowstone National Park is a member of the working group.

Representative: Terry McEneaney

2003 Highlights: Although unable to attend a formal meeting in recent years, the ornithologist plans to attend future meetings.

Integrated Science in Central Yellowstone

Mission: Comprised of scientists from Montana State University, California State University–Monterey Bay, and the Yellowstone Center for Resources, the mission of this group is to build an integrated and multidisciplinary research program dedicated to producing objective science to advance knowledge of the central Yellowstone ecosystem, support sound natural resource management, and communicate knowledge and discoveries to the visiting public to enhance their experience and enjoyment of the park.

Commitment: The Yellowstone Center for Resources is a full partner in this project and has committed resources and staff for the duration of the project.

Representative: P.J. White

2003 Highlights: The partnership was awarded a 5-year, $1.5 million grant from NASA's Office of Earth Science Enterprises (Earth Science REASoN—Education and Application Solutions Network: A Distributed Network of Data and Information Providers for Earth Science Enterprise Science, Applications and Education) to integrate data and models through remote sensing, innovative mapping, and dynamic, interactive, visualization, and provide products and solutions to three broad groups of people involved in the park's decisionmaking processes: 1) park staff who will use the products to make wise decisions, implement solutions, and communicate information to stakeholders; 2) practitioners of wildlife ecology and remote sensing who will benefit from the new, benchmark technologies and approaches for integrating, understanding, and communicating information about the earth's systems; and 3) the park's three million actual visitors and additional "virtual visitors" through the worldwide web and other outreach avenues.

Intermountain Region Natural Resources Communication and Advisory Team

Mission: Intermountain Region Director Karen Wade initiated this team to create more proactive and effective systems to achieve natural resource goals, improve communications, and ensure accountability.

Commitment: Bi-annual meetings and work assignments on the budget and awards workgroups.

Representative: Tom Olliff

2003 Highlights: Implemented a re-engineered process for the Intermountain Region to respond to the Servicewide Comprehensive Funding Call for natural resources; continued publishing the Intermountain Region Natural Resources Newsletter; determined that in 2004 the group would be replaced with a joint Natural–Cultural Resources Advisory Group.

Greater Yellowstone Area Whitebark Pine Subcommittee

Mission: This group includes biologists within the greater Yellowstone area as well as members from academe and state and other federal agencies with a research and management interest in whitebark pine. The mission is to work together to help ensure the long-term viability and function of whitebark pine ecosystems in the GYA.

Commitment: Two meetings.

Representative: Roy Renkin

2003 Highlights: Roy was appointed to a working group to address the needs, feasibility, and successes of whitebark pine restoration. He has also been working with other subcommittee members as well as the Interagency Grizzly Bear Study Team to develop an ecosystemwide inventory and monitoring protocol to assess the health of whitebark pine communities.

Interagency Grizzly Bear Cumulative Effects Modeling Team

Mission: This group includes biologists representing each of the units of the greater Yellowstone area whose mission is to implement and provide line officers with an assessment of grizzly bear habitat conditions and the effects of human activities on grizzly bear habitat for the GYA recovery zone. The purpose and role is to "develop and maintain the Cumulative Effects Model (CEM)/Access database and model, and provide coordination and consistency regarding all aspects of the Yellowstone Ecosystem CEM."

Commitment: Roy Renkin has been the park representative for the past 19 years, and co-chairperson (with Kim Barber of the Shoshone National Forest) for the past eight years. The group met formally once. Roy also worked on an analysis to update model coefficients.

Representative: Roy Renkin

2003 Highlights: Efforts have resulted in a science monograph to be published by the USGS–BRD entitled: Mattson, D., K. Barber, R. Maw, and R. Renkin. In press. Coefficients of productivity for Yellowstone's grizzly bear habitat. USGS–BRD

Science Monograph.

Interagency Grizzly Bear Study Team

Mission: To 1) conduct short- and long-term research addressing information needs for bear management; 2) monitor the bear population, including status and trend, numbers, reproduction, and mortality; 3) monitor grizzly bear habitats, foods, and impacts of humans; 4) provide technical support to agencies and other groups responsible for the immediate and long-term management of grizzly bears in the GYE.

Commitment: Two to four meetings annually. Meetings typically range from one to two days.

Representative: Kerry Gunther

2003 Highlights: In 2003, the IGBST published papers on the use of sulphur isotopes to determine the importance of whitebark pine nuts to grizzly bears; large-carnivore response to recreational big game hunting; and possible effects of elk harvest on the fall distribution of grizzly bears in the GYE.

McLaren Mine Tailings and Great Republic Smelter Reclamation

Mission: The potential reclamation of the McLaren Mine tailings, and other water quality issues in the Cooke City area.

Commitment: Meeting participation.

Representative: Mary Hektner

2003 Highlights: In FY03, Mary participated in several meetings and teleconferences with the Montana Department of Environmental Quality, Gallatin National Forest, Environmental Protection Agency, and environmental groups.

Montana Bird Records Committee

Mission: This interagency group reviews new and rare bird records, and keeps the park up-to-date on the latest advances in ornithology.

Commitment: Meets once or twice a year, depending on the volume of information.

Representative: Terry McEneaney

2003 Highlights: The group reviewed bird records.

Montana Fluvial Arctic Grayling Workgroup

Mission: This group develops short- and long-term goals and works toward the restoration of populations in the upper Missouri basin.

Commitment: A one-day meeting each year plus any required field activities.

Representative: Todd Koel

2003 Highlights: Over 100 grayling at Grebe and Wolf Lakes were tagged as part of a grayling migration survey in the Gibbon River.

Montana/NPS Reserved Water Rights Compact Technical Oversight Committee

Mission: This agreement, signed in 1994 by the NPS and the State of Montana, guarantees that Yellowstone's historical water rights will not be violated and that geothermal aquifers with potential connections to Yellowstone's geyser systems will not be compromised. The agreement quantified Yellowstone's water rights and set up a process to protect these rights from outside development. The compact requires outside developers to demonstrate that no potential exists for adverse effects to the hydrothermal system and that any scientific doubt concerning the effects will be resolved in favor of hydrothermal protection for the park. A technical oversight committee of scientists with hydrothermal system expertise reviews the evidence and oversees the Yellowstone Controlled Groundwater Area.

Commitment: The park representative reviews new water well applications, reports consumptive uses, and monitors data and plans for the Yellowstone Controlled Groundwater Area as needed.

Representative: Hank Heasler

2003 Highlights: The cooperative agreement with the State of Montana for the administration of the water rights in the controlled groundwater area continued in 2003. Members of the Technical Oversight provided comments about Yellowstone's Geothermal Monitoring Plan. Remote sensing is considered an important component for efficiently monitoring all of Yellowstone's geothermal features. Funding is being pursued to implement a comprehensive geothermal monitoring plan for Yellowstone. During 2003, YNP geologist Hank Heasler and members of the NPS Water Resources Division reviewed groundwater use applications for the controlled groundwater area north of Yellowstone.

National Partnership for the Management of Wild and Native Coldwater Fisheries

Mission: This group provides leadership and recommendations for the Whirling Disease Initiative and the Montana Water Center.

Commitment: One three-day meeting each year.

Representative: Todd Koel

2003 Highlights: The partnership explored other possible initiatives. Yellowstone provided research

priorities on whirling disease.

Neotropical Migrant Working Groups

Mission: Yellowstone typically participates in three neotropical migrant working groups. The two state working groups are the Partners in Flight of Montana and Wyoming. The third group, called the Western Working Group Partners in Flight, is international. They are currently focused on prioritizing species and developing conservation plans.

Commitment: Meetings occur twice a year, usually in different areas of the West.

Representative: Terry McEneaney

2003 Highlights: Terry McEneaney was unable to attend meetings in 2003.

New World Mining District Response and Restoration Project

Mission: In 1998, an interagency Memorandum of Understanding (MOU) was established between the U.S. Department of Agriculture, U.S. Environmental Protection Agency, and U.S. Department of Interior. The MOU provides the framework and responsibilities for coordination among federal agencies regarding the development, selection, implementation, and oversight of certain response and natural resource restoration activities, including coordination by the federal agencies with the states of Montana and Wyoming and public participation, in the New World Mining District. The U.S. Forest Service is the lead agency.

Commitment: In FY03, as the Department of Interior's Project Coordinator, Mary Hektner participated in eight public and agency meetings related to the ongoing restoration work, and reviewed, commented upon, and concurred with the forest service's quarterly progress reports to Congress.

Representative: Mary Hektner

2003 Highlights: Mary Hektner prepared and compiled DOI comments on the draft Miller Creek Response Action Engineering and Environmental Cost Analysis (EE/CA), and the draft 2003/2004 New World Response and Restoration Work Plan.

Northern Yellowstone Cooperative Wildlife Working Group

Mission: Member agencies are Montana Fish, Wildlife and Parks, National Park Service (Yellowstone National Park), U.S. Forest Service (Gallatin National Forest), and U.S. Geological Survey (Northern Rocky Mountain Science Center). The overall purpose of this group is to preserve and protect the long-term integrity of the northern Yellowstone winter range by increasing scientific knowledge of its species and habitats, promoting prudent land management activities, and encouraging an interagency approach to answering questions and solving problems. Member agencies share costs and duties for monitoring ungulates on the northern range (inside and outside the park).

Commitment: Bi-annual meetings and work assignments on annual wildlife surveys and reports.

Representatives: Glenn Plumb and P.J. White

2003 Highlights: The Working Group completed cooperative counts and/or classifications of northern Yellowstone bighorn sheep, elk, pronghorn, mule deer, and mountain goats, the results of which were summarized in an annual report.

University of Montana Snowshoe Hare [*Lepus americanus*] Abundance Study

Mission: To document abundance of snowshoe hares in selected YNP forest habitat types.

Commitment: 20 workdays.

Representative: Kerry Murphy

2003 Highlights: To estimate the absolute and relative abundance of snowshoe hares, the University of Montana team conducted fecal pellet counts in a broad range of Yellowstone forest types and deployed four live-trap grids in habitats trapped during 2003. Fecal pellet transect data showed clear differences in relative snowshoe hare abundance across habitats. In general, stands with dense understory cover supported higher hare numbers. These sites were primarily 1988 burns with dense regeneration, although several mature lodgepole or spruce-fir stands also had sufficient understory to support snowshoe hares. Trapping indicated that hares were rare on the four sites that were trapped. Overall, results suggest a patchy distribution for hares across the park.

Wyoming Important Bird Area Technical Review Committee (WIBATRC)

Mission: The WIBATRC is sponsored by Wyoming Audubon, and is responsible for reviewing, designating and implementing important land tracts in Wyoming for bird conservation.

Commitment: Conference calls.

Representative: Terry McEneaney

2003 Highlights: Approximately one dozen new IBAs were reviewed in 2003.

Wyoming Rare Plant Technical Committee

Mission: To coordinate activities between government agencies with rare plant responsibilities, and promote awareness of rare plants statewide.

Commitment: Two days.

Representative: Jennifer Whipple, chairperson

Highlights: Coordinated activities between agencies and started preliminary discussions for the next native plant conservation workshop.

Yellowstone Volcano Observatory

Mission: This cooperative venture between the USGS, Yellowstone National Park, and the University of Utah, created under the USGS Volcano Hazards Program, seeks to monitor earthquake and volcano unrest to improve human safety. The group is in the early stages of developing a Volcano Hazards Response Plan for Yellowstone.

Representative: Hank Heasler

2003 Highlights: The Yellowstone Volcano Observatory website, http://volcanoes.usgs.gov/yvo/, provided real-time data to scientists, interested Yellowstone visitors, and the general public, including the following: live seismograms, an earthquake catalog of the Yellowstone area, GPS station velocities, stream discharge and temperature at Tantalus Creek, stream flow for several major rivers in Yellowstone, and temperature logs for Steamboat Geyser. Non-real-time data included leveling surveys. Scientists affiliated with the Yellowstone Volcano Observatory assisted National Park Service geologists in assessing the possible causes of the dynamic thermal activity at Norris Geyser Basin. Dr. Robert Smith, Professor at the University of Utah, and colleagues from the University NAVSTAR Consortium, and ISS deployed a dense network of high-precision GPS instruments and seismometers in the Norris area from mid-August to early October 2003. These geodetic instruments and seismometers were used to see into the shallow subsurface of the Norris Geyser Basin. Dr. Jake Lowenstern, Scientist in Charge of the Yellowstone Volcano Observatory, assisted park operations by lecturing at the park-wide interpreter training session held in May, and by answering many inquiries concerning geologic activity in Yellowstone.

Professional Support

NPS Servicewide Benefits-Sharing EIS Task Force and Bioprospecting Management Committee

Mission: The National Park Service is considering policy options on how best to manage a small group of permitted researchers in parks commonly characterized as bioprospectors. Bioprospecting is the search for valuable substances in nature, usually bioactive molecules and genetic components, and is an offshoot of permitted research and specimen collection in the national parks. By federal court decree, an EA/EIS process under the authority of the National Environmental Policy Act was chosen to facilitate this process, involve the citizens of our country in the potential decisions, and explore all reasonable alternative management scenarios. Various aspects necessary to this task's completion are being undertaken by the NPS Servicewide Benefits-Sharing EIS Task Force, which consists of the Benefits-Sharing EIS NEPA Team, the EIS's Interdisciplinary Team, and the Washington-level Bioprospecting Management Committee.

Commitment: Yellowstone Park has a greater proportion of bioprospecting occurring in its boundaries than any other park in the system, and thus has a significant commitment to choose the management option that works best for the park and its resources. In 2003, an estimated 2.5 FTE were expended toward this end, partly as a collateral duty.

Representatives: John D. Varley, Sue Mills, and Ann Deutch

2003 Highlights: Yellowstone provided a co-chair (Bioprospecting Management Committee), job captain, and one analyst to the EIS Task Force. The effort was funded through Yellowstone base operations and servicewide planning funds. Work in 2003 included intensive data collection and analyses necessary before the EIS's anticipated release for public comments, scheduled for summer 2004.

Rocky Mountain Cluster Natural Resource Managers Group

Mission: The natural resource chiefs of the Rocky Mountain Cluster meet annually to discuss important cluster resource issues and funding initiatives, and to receive updates on servicewide issues.

Commitment: A two-day annual meeting.

Representative: Tom Olliff (chair through 2003)

2003 Highlights: Held third annual information workshop February 11–12 in Denver.

Thermal Biology Institute and Center for Life in Extreme Environments

Mission: Established by Montana State University–

Bozeman in 1997 to conduct and promote research and education focused on the biology and interrelated physical and chemical processes of geothermal environments in the Greater Yellowstone Ecosystem.

Commitment: An annual meeting, periodic seminars, and administration and logistics associated with their permitted researchers in the park.

Representative: John Varley has a chair on TBI's Scientific Advisory Board; Christie Hendrix services all other commitments.

2003 Highlights: TBI's close proximity to the park provides a unique opportunity for in-depth analysis of life at high temperatures. Nine TBI faculty are leading park projects that range from the discovery and cultivation of new high temperature organisms and viruses, to examination of unique plant–microbe interactions, to understanding the interplay between the geochemical environment and the diversity of thermophilic life. TBI research has resulted in over three dozen publications and invited presentations at national and international meetings, NPS interpretive materials for park visitors, and outreach to regional schools.

Yellowstone River Task Force

Mission: Commissioned by the governor of Montana in 1998 and continued through 2003, this task force seeks to bring together landowners, sportsmen, and community leaders to develop a shared understanding of the issues and competing values and uses that impact the upper Yellowstone River, and encourage a comprehensive approach to action taken along the river to ensure that its integrity remains intact.

Commitment: Monthly meetings and annual field trips. Yellowstone sits on the task force as an ex-officio member.

Representative: Tom Olliff

2003 Highlights: Completed the group's business and disbanded. Submitted a list of 46 recommendations to the Governor of Montana. Held a conference at Chico Hot Springs in October 2003 to present all science findings and recommendations.

Project-Based Partnerships

YCR staff enlist a variety of external partners from universities, federal and state agencies, NGOs, and private groups on a short-term basis to meet some of the park's specific resource stewardship objectives. These partnerships normally last 1–3 years, are formed to achieve very specific objectives, and disband when the objectives are achieved. The following partnerships were active in FY2003:

COOPERATOR/ PARTNER	CONTACT/ PRINCIPAL INVESTIGATOR	PROJECT	BENEFITTING PROGRAM	FUND SOURCE	AMOUNT
A Naturalist's World	Drs. Kerry Murphy (YCR) & James Halfpenny; Kerry Gunther (YCR)	The presence and distribution of lynx (*lynx canadensis*) in Yellowstone	Lynx project	NPS, Yellowstone Park Foundation, National Fish and Wildlife Foundation	$78,000
Bear Creek Council	Julia Page, Rosemary Sucec (YCR)	Support for the potluck welcoming American Indian Tribes to Yellowstone	Ethnography	in-kind	publicity, set-up, food, logistics
California State University–Monterey Bay, Montana State University (Ecology)	Drs. Fred Watson, Robert Garrott, Susan Alexander, & P.J. White (YCR)	Systems integration and visualization of Yellowstone	YCR	NASA	2,500,000
Colorado State University (Chemistry)	Dr. David Grainger, Rick Wallen (YCR)	*Brucella abortus* survivorship during photopolymerization encapsulation	Bison Ecology	ONPS-Bison and Management	23,610
Greater Yellowstone I&M Network, Montana State University (Land, Resources, & Environmental Sciences)	Drs. Lisa Rew & Bruce Maxwell; Cathie Jean	Non-native vascular plant inventory of Yellowstone's northern range	Greater Yellowstone I&M Network	Greater Yellowstone I&M Network	41,000
Greater Yellowstone I&M Network, Wyoming Natural Diversity Database	Cathie Jean, Roy Renkin (YCR), Douglas A. Keinath	Yellowstone bat inventory	Greater Yellowstone	Greater Yellowstone I&M Network	20,000
Idaho State University	Dr. Chuck Peterson, Debra Patla, Cathie Jean	Amphibian inventory	Greater Yellowstone I&M Network	Greater Yellowstone I&M Network	11,500
Michigan Technological University, University of Calgary	Drs. Rolf Peterson, David Mech, Mark Boyce, Evelyn Merrill, & Doug Smith (YCR); Shaney Evans, Julie Mao, Greg Wright, Hawthorne Beyer	Multi-trophic level ecology of wolves, elk, and vegetation in YNP	Wildlife	National Geographic Society, Yellowstone Park Foundation	150,000

COOPERATOR/ PARTNER	CONTACT/ PRINCIPAL INVESTIGATOR	PROJECT	BENEFITTING PROGRAM	FUND SOURCE	AMOUNT
Montana State University (Big Sky Institute), University of Wyoming (American Studies Program, School of Environment and Natural Resources, Office of Research), Buffalo Bill Historical Center (Draper Museum of Natural History)	Drs. Lisa Graumlich, Eric Sandeen, & Charles Preston; Roger Anderson (YCR)	*Beyond the Arch: Community and Conservation in Greater Yellowstone and East Africa* science conference preparations	Resource Information	ONPS-YCR, University of Wyoming (as listed), Draper Museum of Natural History	$17,075
Montana State University (Big Sky Institute), U.S. Agency for International Development (Global Livestock Collaborative Research Program), Colorado State University, State of Montana (Fish, Wildlife & Parks), Tanzania National Parks	Drs. Lisa Graumlich, Glenn Plumb (YCR), Robin Reid & Michael Coughenour; Kurt Alt, Emmanuel Gereta	Managing national parks in the context of changing human populations and economies: a proposal to strengthen collaborations between researchers and managers working in and around Yellowstone and Serengeti parks	YCR	U.S. Agency for International Development (Global Livestock Collaborative Research Program)	100,000
Montana State University (Ecology)	Dr. Tad Weaver, Ken Aho, Cathie Jean, Mary Hektner (YCR)	Describe alpine vegetation of the Absaroka volcanics of YNP	Vegetation	ONPS-Vegetation	46,500
Montana State University (Ecology)	Jennifer Whipple (YCR), Ken Aho, Cathie Jean, Mary Hektner (YCR)	Gallatin Range alpine vascular plant inventory	Greater Yellowstone I&M Network	Greater Yellowstone I&M Network	10,000
Montana State University (Ecology)	Drs. Robert Garrott & P.J. White (YCR)	Evaluating the abundance, distribution, and stress hormones of ungulates in relation to winter human use in west–central YNP	Winter Use Studies	ONPS-Winter Use Monitoring	8,000
Montana State University (Ecology)	Drs. Billie Kerans & Todd Koel (YCR)	Examination of Yellowstone cutthroat trout infection risk as part of the YNP whirling disease study	Aquatic Resources and Fisheries	Fee Demonstration and Fish Fee	33,839
Montana State University (Ecology)	Drs. Robert Garrott, P.J. White (YCR), & Lee Eberhart	Predator–prey relations in a wolf–ungulate system	Wildlife	Yellowstone Park Foundation (Canon Eyes on Hayden), ONPS-Wildlife	37,000
Montana State University (Ecology)	Dr. Robert Garrott, Rick Wallen (YCR), Jason Bruggeman	Spatial dynamics of the central Yellowstone bison herd	Bison Ecology and Management	ONPS-Bison (paid in FY02)	72,000
Montana State University (Ecology)	Drs. Robert Garrott & Glenn Plumb (YCR)	Conduct wildlife research in conjunction with remote Canon cameras (Canon Eyes on Hayden project)	Wildlife	Yellowstone Park Foundation/ Canon, USA	25,000

COOPERATOR/ PARTNER	CONTACT/ PRINCIPAL INVESTIGATOR	PROJECT	BENEFITTING PROGRAM	FUND SOURCE	AMOUNT
Montana State University (Land Resources & Environmental Sciences)	Dr. Rick Lawrence, Shannon Savage (YCR)	Non-forest vegetation mapping and change detection using LANDSAT and ETM imagery in the northern range of YNP	Vegetation	ONPS-Vegetation	$5,000
Montana State University (Land Resources & Environmental Sciences)	Dr. Rick Lawrence, Shannon Savage (YCR), Ann Rodman (YCR)	Remote sensing of non-forest vegetation in Yellowstone's northern range	Spatial Analysis Center	ONPS base funds committed in FY02	28,575
Montana State University (Mathematical Sciences)	Drs. John Borkowski & P.J. White (YCR)	Evaluating wildlife responses to winter human use in YNP	Winter Use Studies	ONPS-Winter Use Monitoring	15,000
Montana State University (MT–USFWS Whirling Disease Initiative)	Drs. Todd Koel (YCR) & Billie Kerans; Silvia Murcia	Development and testing of risk assessment tools for *Myxobolus cerebralis* infection of cutthroat in YNP	Aquatic Resources and Fisheries	MT–USFWS Whirling Disease Initiative	49,690
Montana State University (Museum of the Rockies)	Drs. Leslie Davis & Ann Johnson (YCR)	Various projects, including Section 106 compliance	Archeology	FHWA, ONPS, CRPP base	~70,000
Montana State University (Thermal Biology Institute), Western Oregon University, USGS, Portland State University, Idaho National Engineering and Environmental Laboratory, University of New Mexico	Drs. William Inskeep, Sarah Boomer, Darrell Nordstrom, Anna-Louise Reysenbach, Frank Roberto & Cristina Takacs-Vesbach; Ann Rodman (YCR)	Create a research coordination network for geothermal biology and geochemistry in Yellowstone	Geology/ Geothermal Resources	National Science Foundation	100,000
Montana State University (USFWS Fish Health Lab)	Crystal Hudson, Dr. Todd Koel (YCR)	Laboratory assessment of Yellowstone cutthroat trout whirling disease infection as part of the YNP whirling disease study	Aquatic Resources and Fisheries	National Partnership Whirling Disease Initiative	6,000
Montana State University, University of Wyoming	Drs. Duncan Patten, Dan Tinker, Bob Hall, Cheryl Jaworowski & Glenn Plumb (YCR); Cathie Jean	Develop conceptual ecosystem models for the Greater Yellowstone ecosystem	Greater Yellowstone I&M Network	Greater Yellowstone I&M Network	75,770
National Geographic Society, NPS-WASO-GIS, topo.com, ESRI, USGS	Gavin Maurer, Leslie Armstrong, Ann Rodman (YCR), Matt Heller, John Steffenson, Stanley Ponce	Serving trail and campsite information on the Internet	Yellowstone National Park	NPS-WASO, National Geographic Society	10,000
National Museum of Natural History, Fossil Butte National Monument, NPS International Volunteer Program, Yellowstone Gateway Museum of Park County, Montana	Dr. Ellis Yochelson, Arvid Aase, Anton Gerasimensko, Brian Sparks, Elaine Hale (YCR)	Trilobite Point paleontological resource survey: lab analysis and draft report	Geology/ Paleontology	Yellowstone Park Foundation	12,000

COOPERATOR/ PARTNER	CONTACT/ PRINCIPAL INVESTIGATOR	PROJECT	BENEFITTING PROGRAM	FUND SOURCE	AMOUNT
NPS (Grand Teton National Park), National Elk Refuge	Jacquelin St. Clair, Don DeLong, Rosemary Sucec (YCR)	American Indian use of GRTE, NER, and YELL (traditional use study)	Ethnography	ONPS-CRPP Base	$85,000
NPS (Grand Teton National Park), National Elk Refuge	Jacquelin St. Clair, Don DeLong, Rosemary Sucec (YCR)	An ethnographic overview and assessment for GRTE and NER	Ethnography	ONPS-CRPP Base	59,000
Oregon State University, University of Wisconsin–Stevens Point	Drs. William Ripple & Doug Smith (YCR); Roy Renkin (YCR), Eric Larsen	Aspen regeneration on Yellowstone's northern range	Vegetation	ONPS	5,000
Russian Federation Ministry of Health (Research Centre for Toxicology and Hygienic Regulation of Biopreparations), USDA, Texas A&M University	Drs. Alexander Denisov, Glenn Plumb (YCR), Steven Olsen & Gary Adams	Comparative studies of immunobiological characteristics of live brucellosis vaccines	Bison Ecology and Management	U.S. State Department (Nuclear Threat Initiative)	1,200,000
SeeMore Wildlife	Dr. Glenn Plumb (YCR), Daniel Zatz	Install remote Canon cameras to conduct wildlife research (Canon Eyes on Hayden project)	Wildlife	Yellowstone Park Foundation/ Canon, USA	100,000
Southern Illinois University–Carbondale (Plant Ecology)	Dr. Sedonia Sipes, Jennifer Whipple (YCR)	Pollination and reproductive ecology of *Abronia ammophilia*, a plant endemic to YNP	Vegetation	Yellowstone Park Foundation (Canon Eyes on Yellowstone), National Fish and WIldlife Foundation	39,778
State of Montana (Bureau of of Mines and Geology)	Edmond Deal, Dr. Henry Heasler (YCR)	Yellowstone controlled groundwater area database administration	MT Water Compact	ONPS-Geology	25,033
State of Montana (DEQ)	Elton Erp, Mary Hektner (YCR)	Air quality monitoring at the West Entrance	Winter Use Studies	ONPS-Winter Use Monitoring	40,000
State of Montana (Natural Resources and Conservation, Bozeman)	Scott Compton, Dr. Henry Heasler (YCR)	Yellowstone controlled groundwater area rights administration	MT Water Compact	ONPS-Geology	23,000
State of Wyoming (Fish and Game)	Steve Yekel, Jason Burckhardt, Dr. Todd Koel (YCR), Brian Ertel (YCR)	Life history of Yellowstone cutthroat trout of the upper Yellowstone River	Aquatic Resources and Fisheries	Fish Fee	11,040
Sun Ranch (Madison Valley, Montana)	Roger Lang, Buddy Drake, Dr. Todd Koel (YCR)	Westslope cutthroat trout broodstock development	Aquatic Resources and Fisheries	Fish Fee	5,000
Teton County (Wyoming) Historic Preservation Board	Drs. Alice Richter & Ann Johnson (YCR)	Support for the Osprey Beach project	Archeology	Teton County Historic Preservation Board	1,500

COOPERATOR/ PARTNER	CONTACT/ PRINCIPAL INVESTIGATOR	PROJECT	BENEFITTING PROGRAM	FUND SOURCE	AMOUNT
Texas A&M University, USGS (Biological Resources Division)	Drs. Jim Doerr, Peter Gogan & Glenn Plumb (YCR)	Applications of conservation genetics to the long-term management of bison in the national parks	Bison Ecology and Management	USGS–BRD, NRPP	$210,000
University of Colorado at Boulder (Library Administration)	Bruce Montgomery, Roger Anderson (YCR)	Save America's Treasures: consolidation, inventory, and re-housing of YNP's architectural drawings	Archives	NEH, Save America's Treasures	60,000
University of Minnesota (Fisheries and Wildlife), USGS (Biological Resources Division)	Drs. P.J. White (YCR) & David Mech; Shannon Barber	Multi-trophic level ecology of wolves, elk, and vegetation in YNP (elk calf mortality)	Wildlife	NRPP Natural Resources Management, USGS Park-Oriented Biological Support	89,000
University of Montana (School of Forestry, Wildlife Biology)	Drs. Karen Hodges, Scott Mills & Kerry Murphy (YCR)	Abundance and distribution of snowshoe hare and red squirrels in YNP	Lynx project	Rocky Mountain CESU	10,000
University of Montana (Geology)	Dr. Marc Hendrix, Elaine Hale (YCR)	Paleontological survey and geologic recommendations, Sylvan Pass to East Entrance	Geology/ Paleontology	Federal Highway Administration	20,000
University of Montana (Economics)	Drs. John Duffield & Glenn Plumb (YCR)	What price Yellowstone? The role of wolves in the regional economy	Wildlife	Yellowstone Park Foundation	144,000
University of Montana (Ecology)	Kerry Gunther (YCR), Drs. Glenn Plumb (YCR) & Kathy Tonnessen; Lisa Gerlach	Management of habituated grizzly bears workshop	Wildlife	Rocky Mountain CESU	2,500
University of Montana (Flathead Biological Station), Yellowstone Ecological Research Center	Dr. Robert Crabtree, Ann Rodman (YCR)	ASTER invasive weeds risk mapping	Vegetation	Greater Yellowstone Coordinating Committee	10,000
University of Montana (Flathead Biological Station), YERC	Dr. Robert Crabtree, Roy Renkin (YCR)	Development and utility of multispectral, remotely-sensed imagery to map willow distribution in northern YNP	Vegetation	Fee Demonstration	23,000
University of New Mexico, Portland State University, USGS	Drs. Cristina Takacs-Vesbach, Anna-Louise Reysenbach & Kirk Nordstrom; Ann Rodman (YCR), Jeremy Vesbach, Kendra Maas	A microbial inventory of Greater Yellowstone thermal features	Geology/ Geothermal Resources	National Science Foundation	150,000
University of Oregon (Geography)	Dr. Andrew Marcus, Jim Meacham, Ann Rodman (YCR)	*Atlas of Yellowstone* project	YCR	Yellowstone National Park, University of Oregon	5,000

COOPERATOR/ PARTNER	CONTACT/ PRINCIPAL INVESTIGATOR	PROJECT	BENEFITTING PROGRAM	FUND SOURCE	AMOUNT
University of Utah (Geology and Geophysics)	Drs. Robert Smith & Henry Heasler (YCR)	Seismic and GPS monitoring of Norris Geyser Basin	Geology	ONPS-Geology	$10,000
University of Wyoming (Zoology and Physiology)	Drs. Bob Hall & Todd Koel (YCR); Lusha Tronstad	Trophic consequences of lake trout and whirling disease invasion of Yellowstone Lake	Aquatic Resources and Fisheries	in-kind	boat and logistical support as needed
University of Wyoming (Chemical and Petroleum Engineering)	Dr. Henry Heasler (YCR), Tom Olliff (YCR)	Geologic support to YNP	Geology	ONPS-Geology	57,115
University of Wyoming (NPS Research Center, AMK Ranch)	Dr. Henry Harlow, John Varley (YCR)	Cooperative research program support	Research	ONPS-Research	5,000
University of Wyoming (Office of the Wyoming State Archaeologist)	David Eckles, Dr. Ann Johnson (YCR), Elaine Hale (YCR)	Archaeological investigations for FY2003	Cultural Resources	Federal Highway Administration	62,436
University of Wyoming (OWSA)	David Eckles, Dr. Ann Johnson (YCR), Elaine Hale (YCR)	Archaeological site testing on the Yellowstone and Lamar rivers, YNP	Archeology	FHWA	109,919
University of Wyoming (OWSA)	David Eckles, Elaine Hale (YCR)	Cultural Resource Survey and evaluation of historic road features associated with Firehole Canyon and Firehole Lake drives, YNP	Cultural Resources	Federal Highway Administration	16,000
University of Wyoming (OWSA)	David Eckles, Robert Rosenberg, Elaine Hale (YCR)	Cultural Resource Survey and evaluation of historic road features	Cultural Resources	Federal Highway Administration	13,340
University of Wyoming (Wyoming Cooperative Fish and Wildlife Unit)	Drs. Wayne Hubert & Todd Koel (YCR); Pat Bigelow (YCR)	Predicting lake trout spawning areas in Yellowstone Lake as part of the native Yellowstone cutthroat trout preservation program in YNP	Aquatic Resources and Fisheries	ONPS-Lake Trout	29,268
U.S. Department of Agriculture (Natural Resources Conservation Service)	Dr. Michael Wilson, Ann Rodman (YCR)	Hydrothermally-affected soils of YNP	Spatial Analysis Center	USDA-NRCS	5,000
USDA Forest Service (Bridger-Teton NF), Grand Teton NP	Jamie Schoen, Merry Haydon, Jacquelin St. Clair, Rosemary Sucec (YCR)	Research, inventory, assessment, and coordinated management of wickiups in the Greater Yellowstone Area	Ethnography	ONPS-Ethnography	19,000

COOPERATOR/ PARTNER	CONTACT/ PRINCIPAL INVESTIGATOR	PROJECT	BENEFITTING PROGRAM	FUND SOURCE	AMOUNT
USDA Forest Service [(Clearwater NF), (Nez Perce National Historic Trail)], Nez Perce National Historic Trail Foundation, Yellowstone Historic Center, Confederated Tribes of the Colville Indian Reservation, Confederated Tribes of the Umatilla Indian Reservation, Nez Perce Tribe	Sandi McFarland, Paul Wapato, Paul Shea, Albert Andrews Redstar, Roberta Conner, Vera Sonneck, Rosemary Sucec (YCR)	Creation of a compact-disc recording of the oral histories of elders among the Colville, Nez Perce, and Umatilla Tribes regarding their recollections of the 1877 Nez Perce war and the events that transpired at YNP	Ethnography	USDA Forest Service (Nez Perce National Historic Trail), Nez Perce National Historic Trail Foundation, Yellowstone Historic Center	$7,000
USDA Forest Service (Gallatin NF)	Ann Rodman (YCR)	Development of a Greater Yellowstone Area-wide fuels model and database	GIS/Vegetation	Greater Yellowstone Coordinating Committee	7,500
USDA Forest Service (Nez Perce National Historic Trail)	Sandi McFarland, Rosemary Sucec (YCR)	Oral histories at YNP's 1877 war sites with the Nez Perce elders among the Confederated Tribes of the Colville Indian Reservation, Confederated Tribes of the Umatilla Indian Reservation, and the Nez Perce Tribe	Ethnography	ONPS-Ethnography	6,000
U.S. Geological Survey (Biological Resources Division)	Dr. Peter Gogan, Edward Olexa, Rick Wallen (YCR)	Projecting the demographic consequences of management of Yellowstone bison	Bison Ecology and Management	USGS–BRD	750,000
USGS–BRD	Dr. Peter Gogan, Edward Olexa, Rick Wallen (YCR)	Seasonal habitat selection and movements of of Yellowstone bison	Bison Ecology and Management	USGS–BRD	n/a
USGS–BRD	Dr. Don Despain, Roy Renkin (YCR), Eric Larsen	Browse history of tree-sized aspen on Yellowstone's northern range	Vegetation	ONPS	support as needed
USGS–BRD	Drs. Francis Singer, P.J. White (YCR) & Doug Smith (YCR); Roy Renkin (YCR)	Willow height release and riparian community expansion as a potential consequence of wolf reintroduction	Vegetation	Fee Demonstration	42,480
USGS–BRD (Interagency Grizzly Bear Study Team)	Dr. Charles Schwartz, Mark Haroldson, Kerry Gunther (YCR)	Black bear demographics in YNP	Bear Management	USGS, ONPS Base	As time is available
USGS–BRD, Brigham Young University	Dr. Don Despain, Rex Cates, Roy Renkin (YCR)	Analysis of aspen secondary components	Vegetation	ONPS-Vegetation, USGS Park-Oriented Biological Support	26,100
USGS (Fish Cooperative Research Unit)	Drs. Al Zale & Todd Koel (YCR); Dan Mahony (YCR)	Westslope cutthroat trout restoration in Fan Creek	Aquatic Resources and Fisheries	Unfunded	0

COOPERATOR/ PARTNER	CONTACT/ PRINCIPAL INVESTIGATOR	PROJECT	BENEFITTING PROGRAM	FUND SOURCE	AMOUNT
USGS (Geologic Division, Central Region Minerals Team, Denver)	Drs. Lisa Morgan, Henry Heasler (YCR) & Todd Koel (YCR); Pat Bigelow (YCR)	High-resolution multi-beam bathymetric and seismic reflection survey of Yellowstone Lake as part of the native Yellowstone cutthroat trout preservation program in YNP	Aquatic Resources and FIsheries	Fish Fee	$9,200
USGS (Water Resources Division, Central Region, Denver)	George Ingersoll, Jeff Arnold (YCR)	Analysis of heavy metals deposition in snowpack for correlation between chemical concentrations and snowmachine use	Winter Use Studies	ONPS-Winter Use Monitoring	15,000
USGS–WRD (Montana District)	Robert Davis, Dr. Henry Heasler (YCR)	Assess water discharge and selected chemical and physical parameters of waters in YNP	MT Water Compact	ONPS-Geology	59,450
USGS–WRD (National Water Quality Laboratory, Denver)	Gary Cottrell, Jeff Arnold (YCR)	Analysis of surface water chemistry for volatile organic compounds collected in YNP for correlation between chemical concentrations and snowmachine use	Winter Use Studies	ONPS-Winter Use Monitoring	10,864
USGS–WRD (Utah District)	David Susong, Dr. Henry Heasler (YCR)	Technical expertise and hydrologic assistance to the NPS in the administration of the NPS–State of Montana Water Compact, and with other hydrologic issues	MT Water Compact	USGS–WRD-Competitive, ONPS-Geology	16,000
USGS, Montana Bureau of Mines and Geology, Smithsonian Institution, Fossil Butte National Monument	Drs. Thaddeus Dyman, Douglas Nichols, William Cobban, Karen Porter & Scott Wing; Vincent Santucci, Elaine Hale (YCR)	Cretaceous complexities: the stratigraphic intricacies of Mt. Everts, lab analysis and draft report	Geology/ Paleontology	SEPAS-IMR	29,000
Washington State University, USGS–BRD (IGBST)	Drs. Charles Robbins & Charles Schwartz; Robert Rye, Kerry Gunther (YCR)	Application of stable isotopes and trace elements to understanding potential effects of long-term changes in food resources of Yellowstone's grizzly bears	Bear Management	Yellowstone National Park	6,500
Yellowstone National Park (Division of Maintenance)	Mary Hektner (YCR), Dale Reinhart, Dr. P.J. White (YCR)	Restore native vegetation/pronghorn habitat at former gravel pit/new Yellowstone Research and Heritage Center site	Vegetation/ Wildlife	Yellowstone Park Foundation (Coin, Fund), DOI Cooperative Conservation Initiative	108,000

YELLOWSTONE CENTER FOR RESOURCES

ANNUAL REPORT FY2003